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JUNE 1, 1923.

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HONORARY FELLOWS.

1914. BETHUNE, CHARLES J. S., 16 Washington Ave., Toronto, Canada. (Ch. 1906).
1914. COMSTOCK, JOHN HENRY, Cornell University, Ithaca, N. Y. (Ch. 1906).
1907. CRESSON, EZRA TOWNSEND, Hedgleih, Swarthmore, Pa. (Ch. 1907).
1915. FORBES, STEPHEN ALFRED, University of Illinois, Urbana, Ill. (Ch. 1907).
1914. SCHWARZ, EUGENE AMANDUS, U. S. National Museum, Washington, D. C. (Ch. 1907).

FELLOWS.

1907. ALDRICH, J. M., National Museum, Washington, D. C. (Ch.) Diptera.
1920. ALEXANDER, C. P., Fernald Hall, Massachusetts Agr. College, Amherst, Mass. (1910). Tipulidæ.
1908. BALL, E. D., U. S. Dept. Agr., Washington, D. C. (Ch.) Jassidæ, Cercopidæ, Membracidæ, Fulgoridæ.
1914. BANKS, NATHAN, Museum Comp. Zoology, Cambridge, Mass. (1908).
1913. BARNES, WM., 320 Millikin Bldg., Decatur, Illinois. (Ch.).
1908. BEUTENMULLER, WM., Box 258, Highwood, New Jersey. (Ch.) Cynipidæ.
1920. BEZZI, MARIO, Via Pio Quinto, 3, Torino, Italy. (1918).
1914. BRADLEY, J. CHESTER, Cornell University, Ithaca, N. Y. (Ch.).
1914. BRITTON, W. E., Agr. Exp. Sta., New Haven, Conn. (Ch.). Aleyrodidæ.
1914. BRUES, C. T., Bussey Institution, Boston 30, Mass. (Ch.).
1907. BRUNER, LAWRENCE, Auburn, Calif. (Ch.).
1917. BURGESS, A. F., Melrose Highlands, Mass. (Ch.). Carabidæ.
1917. CAESAR, LAWSON, Ont. Agr. Coll., Guelph, Ontario, Canada. (1912).
1907. CALVERT, P. P., Zool. Lab., Univ. Pennsylvania, Philadelphia. (Ch.). *Odonata.*

1917. Chamberlin, R. V., Museum Comp. Zoology, Cambridge, Mass. (Ch.).
1908. Cockerell, T. D. A., 908 Tenth St., Boulder, Colo. (1907). Bees, Fossil Insects.
1917. Crampton, Guy C., 86 Pleasant St., Amherst, Mass. (1911).
1917. Davis, John J., Agr. Exp. Sta., Lafayette, Ind. (Ch.). Aphididæ, *Lachnosterna*.
1917. Davis, William T., 146 Stuyvesant Place, New Brighton, Staten Island, N. Y. (Ch.). Cicadas, Orthoptera.
1917. Dean, Geo. A., Kansas State Agr. Coll., Manhattan, Kansas. (1913).
1907. Emerton, J. H., 30 Ipswich St., Boston, Mass. (Ch.). Spiders.
1907. Fall, H. C., Tyngsboro, Mass. (Ch.). *Coleoptera*.
1908. Felt, E. P., State Museum, Albany, New York. (Ch.). Itonididæ.
1914. Fernald, H. T., Mass. Agr. Coll., Amherst, Mass. (Ch.). Sphecidæ.
1907. Folsom, J. W., Box 32, Homer, Ill. (Ch). *Collembola, Thysanura*.
1920. Funkhouser, W. D., Univ. Kentucky, Lexington, Ky. (1911). Membracidæ.
1917. Gibson, Arthur, Dominion Entomologist, Ottawa, Canada. (Ch.).
1907. Gillette, C. P., Fort Collins, Colo. (Ch.).
1920. Headley, Thomas J., New Brunswick, N. J. (Ch.).
1917. Hebard, Morgan, Chestnut Hill, Pa. (Ch.). Orthoptera, *Blattidæ*.
1907. Henshaw, Samuel, 28 Fayerweather St., Cambridge, Mass. (Ch.).
1914. Herrick, Glenn W., 219 Kelvin Place, Ithaca, N. Y. (Ch.). Mallophaga, Diaspinæ.
1914. Hine, Jas. S., Ohio State Univ., Columbus, Ohio. (Ch.). Tabanidæ, Asilidæ.
1907. Holland, W. J., Carnegie Museum, Pittsburgh, Pa. (Ch.).
1907. Hopkins, A. D., U. S. Dept. Agr., Washington, D. C. (Ch.).
1907. Howard, L. O., U. S. Dept. Agr., Washington, D. C. (Ch.). Aphelininæ.
1921. Hunter, S. J., University of Kansas, Lawrence, Kansas. (Ch.).
1914. Johannsen, O. A., Roberts Hall, Cornell Univ., Ithaca, N. Y. (Ch.). Diptera.
1907. Johnson, Chas. W., Boston Society Nat. Hist., Boston, Mass. (Ch.). Diptera.
1907. Kellogg, Vernon, Nat. Research Council, 1701 Mass. Ave., Washington, D. C. (Ch.). Mallophaga, Anoplura.
1920. Knaus, W., McPherson, Kans. (Ch.). *Coleoptera*.
1917. Leng, C. W., 33 Murray St., New York City. (1912).
1917. Lutz, Frank E., Amer. Mus. Nat. Hist., New York City. (Ch.).
1920. McDunnough, J., Entomological Branch, Ottawa, Canada. (1912).
1908. MacGillivray, Alex. D., 603 W. Michigan Ave., Urbana, Ill. (Ch.). Saw-flies, Coccids, Insect Morphology.
1908. Marlatt, C. L., U. S. Dept. Agr., Washington, D. C. (Ch.). Cicadidæ, Coccidæ.
1917. Marshall, Wm. S., 139 E. Gilman St., Madison, Wis. (Ch.). Anatomy and Embryology.
1914. Melander, A. L., State Coll., Pullman, Wash. (Ch.). Diptera.
1920. Metcalf, C. L., Nat. Hist. Bldg., Univ. Illinois, Urbana, Ill. (1912). Animal Parasites. *Syrphidæ*.
1914. Morse, Albert P., Peabody Museum, Salem, Mass. (Ch.). Orthoptera.

1920. Mosher, Edna, Univ. New Mexico, Albuquerque, N. M. Immature Insects.
1917. Muir, F., H. S. P. A. Exp. Sta., Honolulu, Hawaii. (Ch.).
1907. Needham, James G., 6 Thurston Ave., Ithaca, N. Y. (Ch.). Odonata, Ephemerida, Plecoptera.
1907. Osborn, Herbert, Ohio State Univ., Columbus, Ohio. (Ch.). Homoptera, *Cicadellidæ.*
1917. Osburn, Raymond C., Botany-Zool. Bldg., Ohio State Univ., Columbus, Ohio. (Ch.). Syrphidæ.
1914. Parrott, P. J., Agric. Exp. Sta., Geneva, N. Y. (Ch.).
1914. Patch, Edith M., Exp. Sta., Orono, Me. (Ch.). Aphiidæ.
1914. Quaintance, A. L., Bur. Entom., Washington, D. C. (Ch.).
1914. Rehn, James A. G., Academy Nat. Sci., Logan Square, Philadelphia, Pa. (Ch.). Orthoptera, Dermaptera.
1914. Riley, W. A., University Farm, St. Paul, Minn. (Ch.). Tabanidæ.
1920. Sanders, J. G., Bur. Plant Ind., Harrisburg, Pa. (Ch.). Cicadellidæ, Coccidæ.
1920. Schaus, William, U. S. Nat. Mus., Washington, D. C. (1919). Lepidoptera.
1920. Shelford, Victor E., Vivarium Bldg., Champaign, Ill. (Ch.). Cicindelidæ, Ecology.
1920. Silvestri, Filippo, R. Scuola Superiore d'Agricoltura, Portici, Italy. (1915). Thysanura, Protura, Termites, Myriopods.
1907. Skinner, Henry, Logan Sq., Philadelphia, Pa. (Ch.). *Rhopalocera.*
1914. Slosson, Annie T., 36 Gramercy Park, New York City. (Ch.).
1921. Swaine, J. M., Dept. Agric., Ottawa, Canada. (1920).
1912. Van Duzee, E. P., Cal. Acad. Sciences, San Francisco, Calif. (Ch.).
1917. Van Dyke, Edwin C., Univ. Calif., Berkeley, Calif. (Ch.). Coleoptera, Elateridæ, Carabidæ.
1914. Walker, E. M., Univ. Toronto, Toronto, Canada. (1910). *Odonata, Orthoptera.* (Canadian species).
1920. Welch, P. S., Univ. Michigan, Ann Arbor, Mich. (1912). Aquatic Lepidoptera.
1907. Wheeler, W. M., Bussey Institution, Boston 30, Mass. (Ch.). Ants.
1914. Wickham, H. F., 911 E. Iowa Ave., Iowa City, Ia. (Ch.). Coleoptera.
1920. Williams, C. B., Ministry of Agric., Cairo, Egypt. Thysanoptera, *Tomaspis.*
1914. Williamson, E. B., Bluffton, Ind. (Ch.). *Odonata.*

MEMBERS.

1908. Ainslie, C. N., 5009 Orleans Ave., Sioux City, Iowa. Hymenoptera, Microhymenoptera.
1907. Ainslie, G. G., R. D. No. 9, Knoxville, Tenn. *Crambinæ, Aphididæ, Jassidæ,* Thysanoptera.
1913. Allee, W. C., Zoology Bldg., Univ. Chicago, Chicago, Ill. Insect Behavior.
1922. Allen, A. R., Jr., B. 22, Give Hall, Cambridge, Mass.
1922. Arnold, George F., State Plant Board, A. & M. College, Miss. Cerambycidæ.

1918. Babcock, O. G., Box 407, Sonora, Texas. Mallophaga and Anopleura.
1922. Baerg, W. J., Fayetteville, Ark.
1919. Baird, A. B., Dom. Ento. Lab., Box 845, Fredericton, N. B., Canada. Parasitic Hymenoptera.
1911. Baker, A. C., East Falls Church, Va. *Aphiidæ* and *Aleyrodidæ*.
1912. Baker, A. W., Ontario Agr. College, Guelph, Canada. *Mallophaga*, Coleoptera.
Ch. Baker, C. F., Los Banos, Philippines. Jassoidea, Fulgoridea.
1922. Baker, Howard, 88 Pleasant St., Amherst, Mass.
1919. Balduf, W. V., University of Illinois, Urbana, Ill. Chrysomelidæ.
1922. Banghart, Joseph, 934 Hollister St., Olney, Ill. *Lepidoptera, Coleoptera.*
Ch. Banks, C. S., Bureau of Science, Manila, Philippines. Diptera, Hemiptera.
Ch. Barber, H. G., 143 Third Avenue E., Roselle, N. J. *Hemiptera-Heteroptera.*
Ch. Barber, H. S., U. S. National Museum, Washington, D. C.
1913. Barber, L. S., Florida State College for Women, Tallahasse, Fla.
Ch. Barlow, John, State College, Kingston, R. I.
1922. Bartley, Hastings N., 40 Hanover Road, Silver Creek, N. Y.
1918. Basinger, A. J., State Insectary, Capital Park, Sacramento, Calif.
1922. Batchelder, Charles H., 38 N. Main St., Orono, Maine.
1914. Baumberger, J. P., 2520 Folsom St., San Francisco, Calif.
1922. Beal, James A., 496 Linwood St., Abington, Mass.
1910. Becker, G. G., State Plant Board, Little Rock, Ark.
1920. Bedford, Hugh W., Khartoum, Sudan, Africa.
1915. Benjamin, F. H., State Plant Board, Agr. College, Miss. *Noctuidæ, Bombyces.*
1914. Bensel, G. E., Spreckels, Calif.
Ch. Bentley, G. M., 406 Morrill Hall, Univ. Tennessee, Knoxville, Tenn.
1917. Bequaert, Joseph, American Museum Natural History, New York City.
1909. Berger, E. W., State Plant Board, Gainesville, Fla.
1920. Berry, Lulu, Vinton, Iowa.
1913. Bethune-Baker, G. T., 20 Newbold Terrace, Leamington Spa., England.
Ch. Betten, Cornelius, 3 The Circle, Ithaca, N. Y. *Trichoptera.*
1913. Bilsing, S. W., College Station, Texas. Cerambycidæ, Orthoptera.
Ch. Bird, Henry, 600 Milton Road, Rye, N. Y. Noctuidæ-*Papaipema.*
Ch. Bishopp, F. C., Box 208, Dallas, Texas. *Ixodoidea*, Siphonaptera, Anopleura.
1913. Blackman, M. W., N. Y. S. Coll. Forestry, Syracuse, N. Y. *Ipidæ, Cerambycidæ*, Buprestidæ.
1918. Blackmore, E. H., Box 221, Victoria, B. C. Canadian Lepidoptera.
Ch. Blaisdell, F. E. Sr., 1520 Lake Street, San Francisco, Calif. *Tenebrionidæ, Melyridæ, Hydrophilidæ.*
1916. Bliss, C. I., Dept. Zoology, Columbia Univ., New York. *Erythroneura on grape.*
1922. Bourne, Arthur I., 12 E. Pleasant St., Amherst, Mass.
1914. Boving, A. G., U. S. Nat. Mus., Washington, D. C. *Coleopterous larvæ.*
1923. Bowen, W. W., Wellcome Tropical Laboratories, Khartoum, Sudan.
1917. Bowers, H. L., 31 N. Eastfield Ave., Trenton, N. J. Lepidoptera.
1922. Boyd, F. W., Box 1094, Billings, Mont. Orthoptera.
1919. Bradley, George H., Mound, La. Diptera.

1922. Branch, Hazel E., 3756 East Douglas Ave., Wichita, Kansas. Chironomidæ, Trichoptera.
1922. Brannon, Clarence H., Box 299, Charlottesville, Va.
Ch. Braun, Annette F., 2702 May St., Cincinnati, Ohio. *Microlepidoptera.*
1923. Brethes, Dr. Juan, Mar Chiquita, 5033, General Urquiza (F. C. C. A.), Buenos Aires, Rep. Argentina.
1921. Brinley, Floyd J., Japanese Beetle Lab., Riverton, N. J. Ecology.
1914. Brolemann, Henry W., Box 22, Pau, Basses-Pyrenees, France.
1919. Bromley, Stanley W., 17 Phillips St., Amherst, Mass. Asilidæ, Tabanidæ.
Ch. Brooks, Fred E., French Creek, W. Va. Fruit and Nut Insects.
1918. Brundrett, H. M., 702 Carter Bldg., Houston, Texas.
1919. Bryan, Edwin H., Bishop Museum, Honolulu, Hawaii. Hawaiian Diptera.
1917. Buchanan, L. L., U. S. Biol. Survey, Washington, D. C. *Rhynchophora.*
Ch. Bueno, J. R. de la Torre, 11 North Broadway, White Plains, N. Y. Aquatic Hemiptera.
1922. Bulger, Jacob W., Dept. Zoology, Ohio State Univ., Columbus, Ohio.
1912. Burrill, A. C., State Board Agr., Jefferson City, Mo. Ants.
1919. Buys, John L., University of Akron, Akron, Ohio. Homoptera.
1922. Bynum, Eli K., Box 331, Gulfport, Miss.
1917. Calder, Edwin E., Longmeadow, R. I.
1914. Cameron, A. E., Univ. Saskatchewan, Saskatoon, Canada. Diptera.
1913. Campbell, Roy E., 200 S. Third St., Alhambra, Calif. Syrphidæ.
1907. Campos, Francisco R., Mus. Natural History, Guayaquil, Ecuador, Apartado No. 484.
1914. Capp, S. B., Box 2054, Philadelphia, Penn.
1915. Carnochan, Frederic G., New City, Rockland Co., N. Y. Coleoptera.
1917. Carr, Frederick S., 222 Fourth St., S. W., Medicine Hat, Alberta. Coleoptera.
1914. Carter, Henry F., Bacteriological Institute, Colombo, Ceylon.
1922. Carter, Walter, Entomological Lab., Lethbridge, Alta., Canada.
1917. Cartwright, W. B., Box 283, Centralia, Illinois.
1912. Casey, Thomas L., Stoneleigh Court, Washington, D. C.
1918. Caudell, A. N., U. S. Nat. Mus., Washington, D. C. *Orthoptera,* Nearctic Neuroptera.
1914. Chaffee, Mrs. Gertrude B., Amenia, North Dakota.
1922. Chamberlin, Joseph C., Box 878, Stanford Univ., Calif. *Pseudoscorpionida,* Coccidæ.
1917. Chambers, E. L., Office of State Entomologist, Madison, Wis.
1914. Champion, H. G., W. Almora Division, Almora, U. P., India.
1921. Chandler, S. C., 402 W. Walnut St., Carbondale, Ill.
1917. Chapin, Edwin A., Bureau Animal Industry, Washington, D. C. *Cleridæ of world,* Siphonaptera, Mallophaga.
1915. Chapman, James W., Silliman Institute, Dumaguete, Negros, P. I.
1914. Chapman, R. N., Dept. Animal Biology, University Farm, St. Paul, Minn.
1917. Chermock, Hugo L., 1308 Tell St., North Side, Pittsburgh, Pa.
1913. Childs, Leroy, Hood River, Oregon.
1918. Claassen, P. W., 102 Irving Place, Ithaca, New York. *Plecoptera.*
1914. Clausen, Curtis P., 2900 Negishi-macpi, Yokahama, Japan. Chalcidoidea, Proctotrypoidea.

1910. Clemens, Mrs. Wilburt A., Dept. Biology, Univ. Toronto, Toronto, Canada.
1917. Coad, B. R., Tallulah, La.
1917. Cole, Charles J., Elkins Park, Penna.
1916. Cole, Frank R., Box 177, Redlands, Calif. Hymenoptera, *Diptera.*
1916. Collins, C. W., Gipsy Moth Lab., Melrose Highlands, Mass. *Calosoma.*
1921. Colman, Wallace, 121 Russell Ave., Ames, Iowa. Diptera.
1921. Compton, C. C., Box 12, Aurora, Ill.
Ch. Cook, Mel T., Experiment Station, Rio Piedras, P. R. Insect Galls.
1919. Cook, William C., Montana State Coll., Bozeman, Mont. *Noctuidæ.*
1910. Cooley, R. A., Montana State Coll., Bozeman, Mont. Coccidæ.
1916. Corcoran, J. A., Loyola College, Montreal, Quebec.
1921. Costa-Lima, Angelo M., Gabinete de Entomologia, Escola Superior de Agricultura Fonseca, Nictheroy (E. do Rio), Brasil. Nycteribiidæ, Cicadidæ.
1915. Cotton, Richard T., U. S. Bur. Entomology, Washington, D. C. *Larvæ of Calandridæ.*
1921. Cowles, Raymond B., 116 Oak Ave., Ithaca, N. Y. Coleoptera, Diptera.
1921. Craighead, Eugène M., Bur. Plant Ind., Harrisburg, Pa. Chrysomelidæ, Siphonaptera.
Ch. Crawford, J. C., 1616 H. St., N. W., Washington, D. C.
1912. Creel, Cecil W., Univ. of Nevada, Reno, Nevada.
Ch. Cresson, E. T. Jr., 11 Amherst Ave., Swarthmore, Pa. Acalyptrate Diptera, *Ephydridæ.*
Ch. Criddle, Norman, Treesbank, Manitoba. Orthoptera, Coleoptera.
Ch. Crosby, C. R., Roberts Hall, Ithaca, N. Y. Spiders.
1914. Crossman, S. S., 17 E. Highland Ave., Melrose Highlands, Mass. Parasitic Hymenoptera.
1915. Curran, C. H., Orillia, Ontario, Canada.
1921. Cutright, C. R., Ohio Agr. Exp. Station, Wooster, Ohio. Aphiidæ.
1914. Dalglish, A. A., 7 Keir St., Pollokshields, Glasgow, Scotland.
1913. Davidson, W. M., Vienna, Va. Syrphidæ.
1922. Davis, Edgar W., Box 438, State Agr. Coll., Manhattan, Kansas.
1914. De Gryse, Joseph J., Charlottesville, Va.
1914. De Long, D. M., Dept. Zoology, Ohio State Univ., Columbus, Ohio. *Cicadellidæ,* Fulgoridæ, Membracidæ.
1919. Detwiler, John D., 693 Queen's Ave., London, Ontario, Canada.
Ch. Dickerson, Edgar L., 106 Prospect St., Nutley, N. J. Homoptera.
1922. Dietrich, Henry, Appleton, N. Y. *Coleoptera.*
1913. Dietz, H. F., 3225 Boulevard Pl., Indianapolis, Ind.
Ch. Dietz, Wm. G., 21 N. Vine St., Hazelton, Pa.
Ch. Doane, R. W., Stanford University, Calif.
1922. Dodds, Clifford T., 201 Agriculture Hall, Univ. Calif., Berkeley, Calif. Callimonidæ.
1922. Doering, Kathleen C., 1214 Tennessee St., Lawrence, Kans. Cercopidæ.
1914. Dognin, Paul, Demt. a Les Pipots, Rue Wimille (Pas-de-Calais), Paris, France.
1922. Dohanian, S. M., 17 E. Highland Ave., Melrose Highlands, 77, Mass.
Ch. Doten, S. B., Experiment Station, Reno, Nevada.

1922. Doucette, Charles F., Greenhouse Insect Lab., Willow Grove, Pa. Greenhouse Insects.
1917. Dowell, Philip, 86 Bond St., Port Richmond, N. Y.
1922. Dowden, P. B., Sandwich, Mass.
1922. Drake, Carl J., Iowa State College, Ames, Iowa. Tingitidæ.
1919. Dunn, Marin S., 4746 Hazel Ave., Philadelphia, Pa. Diptera, Lepidoptera.
1916. Du Porte, E. Melville, Macdonald College, Quebec. Diptera, Ixodoidea.
1917. Duran, Victor, 1554 S. Wilton Place, Los Angeles, Calif.
1914. Dusham, E. H., College Heights, State College, Pa. Coleoptera.
Ch. Easton, Norman, 458 Hight St., Fall River, Mass. Coleoptera.
1913. Edmonston, W. D., Box 1658, Tucson, Arizona. Forest Entomology.
Ch. Edwards, Edwin H., 7317 Clinton Ave., Cleveland, Ohio. Coleoptera.
Ch. Ehrhorn, Edw. M., Box 2520, Honolulu, Hawaii.
1913. Ellis, William O., 10 Court St., Arlington, Mass.
1917. Elrod, M. J., Missoula, Mont.
1911. Ely, Charles R., 6 Kendall Green, Washington, D. C. Gracilariidæ.
1919. Emerson, Alfred, Dept. of Zoology, Univ. Pittsburgh, Pittsburgh, Pa. *Termites.*
1922. Emery, George, 249 Lakeside Ave., Marlboro, Mass.
1914. Enburg, John M., 5207 Baltimore Ave., Philadelphia, Pa.
Ch. Engelhardt, George P., Museum, Eastern Parkway, Brooklyn, N. Y. Aegeriidæ.
1922. Esaki, Teiso, Ento. Lab., Coll. Agr., Kiushiu, Imperial Univ., Fukukoa, Japan. Heteroptera.
1910. Essig, E. O., Room 201 A. H., Univ. Calif., Berkeley, Calif. *Aphididæ,* Coccidæ.
1914. Evenden, James L., Coeur d'Alene, Idaho. Forest Entomology.
Ch. Ewers, William V., 44 N. Goodman St., Rochester, N. Y. Diptera.
1910. Ewing, H. E., U. S. Nat. Museum, Washington, D. C. Acarina-Protura-Mallophaga-Arachnida-Anoplura-Siphonaptera.
1918. Eyer, John R., Univ. Club, State College, Pa.
1917. Fackler, Harry L., State Entomologist's Office, Knoxville, Tenn.
1917. Fattig, P. W., 207 Pine St., Farmville, Va.
1923. Faz, Alfredo, Bandera No. 714, Santiago, Chile, South America.
1915. Fenton, F. A., Dept. Entomology, State Coll., Ames, Iowa. Anteoninæ.
1914. Ferris, G. F., Stanford Univ., Calif. Coccidæ, ectoparasites.
Ch. Field, W. L. W., Milton Academy, Milton, Mass. Lepidoptera, Orthoptera.
1922. Filinger, George A., Box 6, Kansas State Agr. Coll., Manhattan, Kansas.
1910. Fink, D. E., Riverton, N. J.
1907. Fisher, W. S., U. S. Nat. Mus., Washington, D. C. *Buprestidæ; Cerambycidæ.*
1922. Fleming, Andrew, Sibley, Adams Co., Miss.
1922. Fletcher, Frank C., 2816 W. 44th St., Minneapolis, Minn. Coleoptera, Tenebrionidæ.
1919. Fletcher, Robert K., College Station, Texas. Heteroptera.
1908. Flint, W. P., Natural History Bldg., Urbana, Ill.
1919. Florence, Laura, Box 284, Princeton, N. J. Siphunculata.
1908. Forbes, William T. M., 23 Trowbridge Road, Worcester, Mass. Lepidoptera of *Northeastern States.*

1922. FORD, NORMA, 96 Dunn Ave., Toronto, Ontario, Canada.
1916. FORTUN, GONZOLA M., Calle 9, No. 5, Santiago de las Vegas, Cuba.
1919. FOURNIER, MRS. GASTON, 90 Boulevard, Malesherbes, Paris (8) France. Lepidoptera.
1912. FOX, HENRY, Mercer Univ., Macon, Ga. *Orthoptera*, Cicindelidæ, Scarabaeidæ.
1911. FRACKER, S. B., State Capitol, Madison, Wis. Coreidæ.
1922. FRANCE, L. V., University Farm, St. Paul, Minn. Apiculture.
1918. FRANK, ARTHUR, Puyallup, Wash.
1922. FRIEND, ROGER B., 23 Ashmont St., Dorchester, Mass. Diptera, Hymenoptera, Hemiptera.
1914. FRISON, T. H., Nat. Hist. Bldg., Urbana, Ill. *Bremidæ*.
Ch. FROST, C. A., 67 Henry St., Framingham, Mass. *Coleoptera*.
1914. FROST, S. W., Arendtsville, Pa. *Phytomyza*, Agromyzidæ.
Ch. FULLAWAY, D. T., 1430 Kewalo St., Honolulu, Hawaii. Hymenoptera. Braconidæ.
1916. FULTON, B. B., Oregon Agric. Coll., Corvallis, Oregon. Orthoptera.
Ch. GAHAN, A. B., Berwyn, Md. Chalcidoidea, Braconidæ.
1916. GAIGE, FREDERICK M., Museum of Zoology, Univ. Mich., Ann Arbor, Mich. *Formicidæ*.
1922. GARLICK, W. GILBERT, 302 Museum, Univ. Kansas, Lawrence, Kansas. Tethhredinoidea.
1914. GARMAN, PHILIP, Conn. Agr. Exp. Sta., New Haven, Conn. *Odonata*, Acarina.
1917. GARNETT, R. T. DE, 583 Merrimac St., Oakland, Calif. *Buprestidæ*, *Cicindelidæ*.
1918. GARRISON, G. F., Bureau of Entomology, Washington, D. C.
1922. GEHRING, JOHN GEORGE, Bethel, Maine.
1916. GENTNER, LOUIS G., 213 Bailey St., East Lansing, Mich. *Halticini*.
Ch. GERHARD, WM. J., Field Mus. Nat. Hist., Chicago, Ill. Hemiptera.
1922. GERRY, BERTRAM, 7 Howard Ave., Peabody, Mass. Diptera, Coleoptera.
1912. GIBSON, E. H., R. D. No. 1, Alexandria, Va.
1913. GIBSON, FRANK M., 235 W. Lafayette Ave., Baltimore, Md. Lepidoptera.
Ch. GIFFARD, W. M., Box 308, Honolulu, Hawaii.
1922. GILMER, PAUL M., Div. of Ento., Univ. Farm, St. Paul, Minn.
1916. GLASER, RUDOLF W., Rockefeller Inst. for Medical Research, Princeton, N. J. Pathology of Insects.
1911. GLASGOW, HUGH, Experiment Station, Geneva, N. Y.
1911. GLASGOW, ROBERT D., Nat. Hist. Bldg., Urbana, Ill. *Phyllophaga*.
1919. GLICK, PERRY A., State Entomological Bldg., Phoenix, Arizona.
1916. GOOD, A. I., 3485 Townsend Ave., Detroit, Mich.
1921. GOOD, HENRY G., Dept. Ento., Cornell Univ., Ithaca, N. Y., Coleoptera.
1908. GOODWIN, W. H., Wooster, Ohio.
Ch. GOSSARD, H. A., Agric. Exp. Sta., Wooster, Ohio. Orthoptera, Hemiptera.
Ch. GRAENICHER, SIGMUND, Box 14, Larkins, Fla. Aculeate Hymenoptera; Muscoid Diptera.
1917. GRAHAM, SAMUEL A., Univ. Farm, St. Paul, Minn. Scolytidæ-Cerambycidæ-Buprestidæ.

1922. Granovsky, Alexander A., 1532 University Ave., Madison, Wis. Aphididæ.
1914. Greene, Charles T., Box 51, East Falls Church, Va.
1917. Grinnell, Fordyce, Hilo, Hawaii.
1919. Griswold, Grace H., 126 Roberts Place, Ithaca, N. Y.
1914. Guberlet, John E., A. & M. Coll., Stillwater, Okla.
1913. Gunn, David, Box 597, Port Elizabeth, S. Africa.
1916. Guyton, T. L., Bur. of Plant Ind., Dept. of Agr., Harrisburg, Pa.
1921. Guyton, F. E., Auburn, Ala. Blattidæ.
1916. Hadwen, S., U. S. Biological Survey, Washington, D. C.
1914. Hagan, Harold R., Univ. Utah, Salt Lake City, Utah. Diptera.
1922. Hall, Maurice C., Zoological Div. Bur. An. Ind., Washington, D. C. Parasites of domestic animals.
1921. Hallock, Harold C., Weatherly, Pa. Diptera.
1914. Hallinen, J. E., Cooperton, Kiowa Co., Oklahoma.
1914. Hamilton, C. C., Univ. Md., College Park, Md. Larvæ of *Cicindelidæ* and *Carabidæ*.
1916. Hamlin, John C., Box 509, Uvalde, Texas. *Membracidæ,* Homoptera.
1922. Hamner, A. L., Box 1252, Auburn, Ala. Aphididæ.
Ch. Hansen, James, St. John's Univ., Collegeville, Minn.
1922. Harington, R. J., 86 Pleasant St., Amherst, Mass.
1907. Harned, R. W., State Plant Board, Agricultural College, Miss.
1922. Hartley, Edwin A., N. Y. State Coll. of Forestry, Syracuse, N. Y. Parasitic Hymenoptera.
1920. Hartzell, Albert, Dept. Entom., Agr. Exp. Station, Geneva, N. Y. *Empoasca;* Orgerini.
1907. Hartzell, Frederick Z., 321 W. Main St., Fredonia, N. Y. Coleoptera.
1921. Harwood, R. D., Claremont, Calif.
Ch. Haseman, L., Univ. of Missouri, Columbia, Mo.
1919. Hatch, Melville H., Zoology Dept., Univ. Mich., Ann Arbor, Mich. *Histeridæ, Silphidæ.*
1919. Hayes, Wm. P., Kans. State Agr. Coll., Manhattan, Kansas.
1923. Herbst, Paul, Casilla 3528, Valparaiso, Chile. Hymenoptera.
1920. Hertig, Marshall, Dept. Animal Biol., Univ. Minn., Minneapolis, Minn. Insect Symbionts.
1916. Hess, Walter N., De Pauw Univ., Greencastle, Ind.
1908. Heywood, Mrs. R. S., Webster City, Iowa.
1919. Hill, C. C., U. S. Entom. Lab., Carlisle, Pa. Embryology and ecology of Hymenoptera.
1908. Hilton, W. A., Claremont, Calif.
Ch. Hinds, W. E., Ala. Exper. Sta., Auburn, Ala.
Ch. Hodgkiss, H. E., Botany Bldg., State College, Pa. Eriophyidæ.
1917. Hofer, Geo., Entom. Ranger, Box 1658, Tucson, Arizona. Forest Insects.
1914. Hoffman, Wm. A., Johns Hopkins Univ., Baltimore, Md.
1919. Hoffman, William E., Div. of Entom., Univ. Farm, St. Paul, Minn. *Aquatic Heteroptera.*
1919. Hoke, Gladys, 1104 M Street, N. W., Washington, D. C. *Coccidæ.*
1913. Holloway, T. E., Sugar Expt. Sta., Audubon Park, New Orleans, La.
1912. Hood, C. E., Melrose Highlands, Mass.

Ch. HOOD, J. D., 104 Chestnut St., Rochester, N. Y.
1913. HORTON, JOHN R., 126 S. Minneapolis Ave., Wichita, Kans. *Phyllophaga.* Thysanoptera.
Ch. HOUSER, J. S., Ohio Agr. Exp. Sta., Wooster, Ohio. Coccidæ.
Ch. HOWARD, CHARLES T., 1735 East Ave., Rochester, N. Y. Lepidoptera.
1907. HOWARD, CHAS. W., Christian College, Canton, China.
1914. HOWARD, NEALE F., Drawer E, Woodlawn P. O., Birmingham, Ala.
1917. HOWE, R. HEBER, JR., 58 Highland St., Cambridge, Mass. Odonata.
1914. HOWES, GEORGE, 432 George St., Dunedin, New Zealand. Ephemeridæ.
Ch. HUARD, V. A., 2 Richelieu St., Quebec, Canada. Lepidoptera.
1921. HUBER, L. L., 111 E. Main St., Geneva, Ohio. Chalcidoidea.
1921. HUCKETT, H. C., Box 152, Riverhead L. I., N. Y. *Anthomyiinæ.*
1922. HULL, FRANK M., Dept. Entom., Ohio State Univ., Columbus, Ohio. *Syrphidæ, Stratiomyidæ, Tabanidæ.*
1909. HUNGATE, J. W., State Normal School, Cheney, Wash.
1916. HUNGERFORD, H. B., Dept. Entom., Lawrence, Kansas. *Corixidæ, Nepidæ, Notonectidæ, Hydrometridæ,* Aquatic Hemiptera.
Ch. HUNTER, W. D., Carter Bldg., Houston, Texas.
1917. HUSSEY, ROLAND F., Bussey Institution, Boston 30, Mass. *Hemiptera.*
1908. HYSLOP, J. A., Bureau of Entomology, Washington, D. C. Elateridæ.
1911. ILLINGWORTH, J. F., Meringa near Cairns, North Queensland, Australia.
1914. ISELY, DWIGHT, Agr. Exp. Sta., Fayetteville, Ark. Eumenidæ.
1922. ISHIMORI, NAOTO, Ueda, Shinano, Japan. Lepidoptera.
1907. JACKSON, C. F., Durham, N. H. Ecology.
1915. JACKSON, L. O., 317 E. Carr Ave., Cripple Creek, Colo. *Aphilanthops.*
1920. JAQUES, H. E., Mt. Pleasant, Iowa. Phyllophaga.
1910. JENNINGS, H. R., Lowell High School, San Francisco, Calif.
1915. JEWETT, H. H., R. R. No. 2, Lexington, Ky.
Ch. JOHNSON, S. A., 612 Elizabeth St., Fort Collins, Colo.
1917. JONES, C. R., Colo. Agric. Coll., Fort Collins, Colo.
Ch. JONES, FRANK M., 2000 Riverview Ave., Wilmington, Delaware. *Psychidæ.*
1916. KAHL, HUGO, Carnegie Mus., Pittsburgh, Pa. Odonata.
1921. KEEN, SADIE E., Drawer J., Forest Grove, Ore. Cereal and Forage Insects.
Ch. KELLER, GEORGE J., 68 Treacy Ave., Newark, N. J. Catocalæ.
1914. KENNEDY, CLARENCE H., Entom. Dept., Ohio State University, Columbus, Ohio. Odonata.
1921. KESSEL, MRS. QUINTA CATTELL, Garrison, N. Y.
Ch. KINCAID, TREVOR, Univ. Washington, Seattle, Wash. *Psychodidæ.* Tenthredinoidea.
1914. KING, H. H., Wellcome Tropical Research Lab., Khartoum, Anglo-Egyptian Sudan, S. Africa.
1912. KING, J. L., 3233 Carnegie Ave., Cleveland, Ohio. Tachinidæ of Japan.
1923. KING, KENNETH M., Univ. Saskatchewan, Saskatoon, Sask., Canada.
1919. KING, ROBERT L., Zool. Lab., Univ. Pa., Philadelphia, Pa. Orthoptera.
1918. KINSEY, ALFRED C., 620 S. Fess St., Bloomington, Ind. *Cynipidæ.*
1916. KISLIUK, MAX, JR., 134 S. Second St., Philadelphia, Pa. Muscidæ.
1920. KNAPP, MRS. CHARLES M., 437 Waverly Ave., Syracuse, N. Y.
1911. KNIGHT, HARRY H., Univ. Farm, St. Paul, Minn. Heteroptera, *Miridæ.*
1922. KNIGHT, PAUL, Dept. Entom., Urbana, Ill.

Ch. Kotinsky, Jacob, 5154 Parkside Ave., Philadelphia, Pa. Adelginæ (Chermes).
1917. Kraatz, Walter C., Zoology Bldg., Ohio State Univ., Columbus, Ohio.
1914. Laake, E. W., Box 208, Dallas, Texas. Diptera.
1922. Lackey, James, 146 Waycaster Pl., Jackson, Miss. Coleoptera.
1919. Lacroix, Don, 90 Pleasant St., Amherst, Mass.
Ch. Lagai, George, 440 Bedford Ave., Richmond Hill, L. I., N. Y.
1919. Lambert, Floyd, 4321 Walnut St., Philadelphia, Pa.
1912. Lamkey, Ernest M. R., Agr. Exp. Sta., Newark, Delaware.
1917. Lane, M. C., Box 498, Ritzville, Wash.
Ch. Lang, Joseph N., 1433 S. 59th Ave., Cicero, Ill.
1917. Lange, Rich. C., U. S. Entom. Lab., 628 Yeddo Ave., Webster Groves, Mo. Catocala.
1917. Langston, J. M., A. & M. College, Miss. Phyllophaga.
1914. Larrimer, W. H., Box 95, W. Lafayette, Ind. *Cicadellidæ.*
1913. Lathrop, Frank H., Experiment Station, Geneva, N. Y. Cicadellidæ.
1919. Lathy, Percy I., 90 Bd. Malesherbes, Paris, France. Lepidoptera.
Ch. Laurent, Philip, 31 E. Mt. Airy Ave., Philadelphia, Pa.
1917. Lawson, Paul B., 605 Maine St., Lawrence, Kansas. Homoptera, *Cicadellidæ.*
1922. Learned, Elmer T., 46 Franklin St., Fall River, Mass. Lepidoptera, Arctiidæ.
1912. Leiby, R. W., State Dept. Agric., Raleigh, N. C. Insect Polyembryony.
Ch. Liljeblad, E., 1018 Roscoe St., Chicago, Ill.
1917. Lindsey, A. W., Box 782, Granville, Ohio. *Hesperioidea of world; Pterophoridæ of N. A.*
1914. Littler, Frank M., Box 114, Lannceston, Tasmania, Australia.
Ch. Lloyd, J. T., 34 Walnut Ave., Wyoming, Hamilton Co., Ohio.
Ch. Lochhead, W., Macdonald College, Quebec, Canada.
1919. Lockwood, Stewart, Box 1094, Billings, Mont. Orthoptera.
1922. Lounsbury, Charles P., Box 513, Pretoria, S. Afr.
1917. Lovett, A. L., Agric. Coll., Corvallis, Oregon.
1919. Lowry, P. R., New Hampshire Coll., Durham, N. H. *Coccidæ, Mealy Bugs.*
1913. Luginbill, Philip, U. S. Entom. Sta., Columbia, S. C. Phyllophaga.
1917. Lundbeck, Wm., Zoological Museum, Copenhagen, Denmark. Diptera.
1922. Lutken, Alfred, Logtown, Miss.
1914. McAtee, W. L., Biolo. Sur., U. S. Dept. Agric., Washington, D. C. *Heteroptera, Homoptera, Diptera.*
1920. McBride, O. C., Whitten Hall, Columbia, Mo.
1917. McColloch, James W., Agric. Exp. Sta., Manhattan, Kans. *Scarabaeidæ, Tenebrionidæ.*
1907. McCracken, Miss Isabel, Stanford Univ., Calif., Box 44. *Cynipidæ,* Apoidea.
1910. McDaniel, Eugenia, I., Agric. Coll., East Lansing, Mich.
1911. McIndoo, N. E., Bur. Entom., Washington, D. C. Insect Physiology.
1919. McMahon, Arthur, 9 Dalhousie St., Montreal, Canada. Hymenoptera.
1921. McNeill, Jerome, Thonotosassa, Fla. Orthoptera.
1917. Maheux, Geo., Parliament Bldg., Quebec, Canada.

1922. MANK, EDITH W., 12 Reservoir St., Lawrence, Mass. Coleoptera.
1921. MANK, HELEN GARDNER, 12 Reservoir St., Lawrence, Mass.
Ch. MANN, B. PICKMAN, 1918 Sunderland Place, Washington, D. C.
1913. MANN, WILLIAM M., U. S. Nat. Mus., Washington, D. C. *Formicidæ, Ant Guests, Termitophiles.*
1922. MARCOVITCH, SIMON, Univ. Tenn., Knoxville, Tenn.
1921. MASON, ARTHUR C., Box 576, Lindsay, Calif. Thrips.
1912. MASON, P. W., U. S. Bur. Entom., Washington, D. C. *Aphiidæ.*
1916. MASON, SHIRLEY L., 5554 Avondale Place, Pittsburgh, Pa.
Ch. MATHESON, ROBERT, Cornell Univ., Ithaca, N. Y. *Ixodoidea, Culicidæ,* Parasitic Insects.
1917. MAY, RAOUL M., 106 Hammond St., Cambridge, Mass.
1909. MATCALF, Z. P., State College Sta., Raleigh, N. C. Homoptera.
1917. MICKEL, CLARENCE E., Box 417, Rocky Ford, Colo. Sphecoidea, Mutillidæ.
1922. MIDDLETON, WILLIAM, Bur. of Entom., Washington, D. C. Chalastogastrous larvæ.
1921. MILLER, AUGUST E., Care of Ross County Farm Bureau, Chillicothe, Ohio. Mites.
Ch. MILLER, ELLEN ROBERTS, 115 W. High St., Painesville, Ohio.
1921. MITCHELL, THEO. B., State Dept. Agric., Raleigh, N. C. Apoidea.
1921. MOFFATT, ELIZABETH M., Wheaton, Ill. *Araneida.*
1922. MONTGOMERY, BASIL E., Poseyville, Ind. Coleoptera, Lepidoptera.
1908. MOORE, WILLIAM, American Cyanimid Co., 511 Fifth Ave., New York.
1923. MOREIRA, CARLOS, Rau Sta. Clara 26, Copacabana, Rio de Janeiro, Brazil.
1908. MORGAN, ANN H., South Hadley, Mass. Ephemeridæ.
Ch. MORGAN, H. A., Univ. of Tenn., Knoxville, Tenn.
Ch. MORRILL, A. W., 382 W. Ave., 53, Los Angeles, Calif. Aleyrodidæ.
1917. MORRIS, FRANCIS J. A., 643 Aylmer St., Peterborough, Ont., Canada.
1922. MORRIS, WALTER MARKLEY, 44 Triangle St., Amherst, Mass.
1912. MORRISON, HAROLD, Federal Horticultural Board, Washington, D. C.
1914. MOSELEY, MARTIN E., 94 Campden Hill Road, Kensington, London, Eng. Trichoptera, Ephemeridæ, Plecoptera, Scent Organs.
Ch. MOSHER, F. H., 17 E. Highland Ave., Melrose Highlands, Mass.
1920. MOTE, DON C., Box 348, Phoenix, Arizona.
1915. MUSEBECK, C. F. W., 17 E. Highland Ave., Melrose Highlands, Mass. Braconidæ, *Microgasterinæ, Meteorinæ.*
1917. MUTCHLER, ANDREW J., Amer. Mus. Nat. Hist., New York City. Lampyridæ.
1915. MUTTKOWSKI, R. A., Univ. of Idaho, Moscow, Idaho. Aquatic Insects.
1907. MYERS, P. R., U. S. Entom. Lab., Carlisle, Pa.
1921. NAUDE, T. J., Botany-Zoology Bldg., Columbus, Ohio. Cicadellidæ.
1912. NEILLIE, CHAS. R., 4317 E. 116th St., Cleveland, Ohio.
1921. NEILSON, ERNEST, Care of Chris E. Olsen, Amer. Mus. Nat. Hist., New York City.
1921. NEISWANDER, C. R., Dept. Entom., Ohio State Univ., Columbus, Ohio.
1907. NELSON, JOS. A., Route 3, Mt. Vernon, Ohio.
Ch. NESS, H., 821 Kellogg Ave., Ames, Ia.

Ch. NEWCOMB, W. W., 90 Webb Ave., Detroit, Mich. Lycaenidæ, Notodontidæ, Noctuidæ.
Ch. NEWCOMER, E. J., Box 243, Yakima, Wash. Thysanoptera.
1907. NEWELL, WILMON, Agric. Exp. Sta., Gainesville, Fla.
1915. NEWMAN, GEORGE B., Univ. Club, State College, Pa.
1919. NININGER, H. H., 310 College St., Winfield, Kansas.
1922. NOBLE, W. B., Box 95, W. Lafayette, Ind.
1917. NOTMAN, HOWARD, 136 Joralemon St., Brooklyn, N. Y. *Carabidæ*, Staphylinidæ, *Stenus*.
1908. O'KANE, W. C., State College, Durham, New Hampshire.
1916. OLSEN, CHRIS E., Amer. Mus. of Nat. Hist., New York City. Cicadellinæ.
1908. OSBORN, H. T., H. S. P. A. Exper. Sta., Honolulu, Hawaii.
Ch. OSLAR, ERNEST J., Denver, Colo., 4535 Raleigh St.
1920. OTANES, FAUSTINO Q., Bureau of Agric., Manila, Philippine Islands.
1917. OUELLET, JOSEPH, 1145 St. Viateur St., Outremont, Quebec.
1915. PACKARD, C. M., 600 Twenty-sixth St., Sacramento, Calif.
1913. PADDOCK, F. B., Sta. A., Ames, Iowa. Apiculture.
1918. PAINTER, H. R., U. S. Entom. Lab., Box 95, W. Lafayette, Ind. Orthoptera.
1919. PAINTER, REGINALD H., Address unknown.
1918. PARKER, J. B., 1217 Lawrence St., N. E., Washington, D. C. Bembecidæ.
1916. PARKER, R. R., Hamilton, Mont. *Sarcophagidæ*.
1916. PARKS, H. B., Box 838, San Antonio, Texas. Apiculture.
1918. PARKS, T. H., Ohio State Univ., Columbus, Ohio.
1912. PARSHLEY, H. M., Smith College, Northampton, Mass. Heteroptera.
Ch. PAXSON, OWEN S., Radnor, Delaware Co., Pa.
1919. PEAIRS, L. M., Morgantown, W. Va. Mallophaga, Thysanoptera.
1920. PEARSON, GEORGE B., Box 95, W. Lafayette, Ind. Buprestidæ.
1922. PEARSON, JOHN C., 116 Pleasant St., Amherst, Mass.
1911. PETERSON, ALVAH, Rutgers College, New Brunswick, N. J. Diptera.
1907. PETRUNKEVITCH, ALEXANDER, Osborn Zool. Lab., Yale Univ., New Haven, Conn. Arachnida.
Ch. PETTIT, R. H., Agric. Exper. Sta., East Lansing, Mich. Coccidæ.
1921. PHILLIPS, E. F., Bureau of Entom., Washington, D. C. Apiculture.
1912. PHILLIPS, W. J., U. S. Entom. Lab., Box 299, Charlottesville, Va. *Harmolita*.
Ch. PIERCE, W. DWIGHT, San Mateo, Calif. Rhynchophora, *Strepsiptera*.
1913. POOS, FRED W., Care of European Corn Borer Lab., Sandusky, Ohio. *Harmolita*, *Bombidæ*.
1918. POPE, THOMAS E. B., Public Museum, Milwaukee, Wis.
1921. POTGIETER, JOHANNES, Box 32, Zastrom, O. F. S., S. Africa.
Ch. POWELL, P. B., Clinton, N. Y.
1915. POWERS, EDWIN BOOTH, Univ. of Tennessee, College Medicine, Memphis, Tenn.
1916. PRICE, W. A., Purdue Univ., Lafayette, Ind.
1916. PSOTA, FRANK J., 4046 W. 26th St., Chicago, Ill. Cetonidæ.
Ch. RAMSDEN, CHAS. T., Apartado 146, Guantanamo, Cuba. Lepidoptera, *Sphingidæ*.
1923. RANDOLPH, ABRAHAM M., Casilla 1, Valdivia, Chile, S. Amer.

1913. RAU, PHIL, 2819 S. Kingshighway Blvd., St. Louis, Mo. Aculeate Hymenoptera.
1923. REED, WILLIAM D., Ent.-Zool., Clemson College, S. C.
1922. REED, W. V., State Capitol, Atlanta, Ga. Insects of Ornamental Plantings.
1919. REEHER, MAX M., Forest Grove, Oregon. Cereal and Forage Insects.
1908. REGAN, W. S., Montana State Coll., Bozeman, Mont. Psammocharidæ.
1917. REIS, JACOB A., JR., Edea, Cameroun, West Africa.
1921. REMY, T. P., Box 225, College Station, Texas.
1918. RESSLER, I. L., Dept. Entom., Iowa State Coll., Ames, Iowa.
1914. RICHARDSON, CHARLES H., Bureau of Entomology, Washington, D. C. Insect Physiology.
1922. RIES, DONALD T., 401 Thurston Ave., Ithaca, N. Y. Hymenoptera.
1914. RIS, F., Rheinau, Canton Zurich, Switzerland.
1922. ROBERTS, H. E., U. S. Entom. Lab., Webster Groves, Mo. Rhyncophora.
1915. ROBINSON, J. M., Box 264, Auburn, Ala. Coccidæ, Coleoptera.
1913. ROCKWOOD, L. P., Forest Grove, Ore.
1922. RODRIGUEZ, MAURO G., State Coll., Bozeman, Mont. Tropical Insects.
1915. ROGERS, J. SPEED, Univ. Florida, Gainesville, Fla. Tipuloidea, *Erioptera*.
1922. ROOT, FRANCIS M., School Hyg. & Pub. Health, 310 W. Monument St., Baltimore, Md. Diptera, *Anopheles*.
1914. ROSENFELD, ARTHUR H., 2142 Sixteenth Ave., S., Birmingham, Ala.
1912. ROSS, WILLIAM A., Dominion Entom. Lab., Vineland Sta., Ontario. *Aphididæ*.
1921. ROWLEY, R. R., 1115 N. C. St., Louisiana, Mo. *Catocala*, *Sphingidæ*, *Nymphalidæ*.
1914. RUCKES, HERBERT, 1171 Sherman Ave., New York City.
Ch. RUGGLES, A. G., University Farm, St. Paul, Minn.
Ch. RUMSEY, W. E., Agric. Exp. Sta., Morgantown, W. Va.
1922. SAMPSON, HOWARD, Osborn Zool. Lab., New Haven, Conn. Parasitic Insects.
1907. SANDERS, G. E., Entom. Lab., Annapolis Royal, N. S., Canada.
Ch. SASSCER, E. R., 1225 Decatur St., N. W., Washington, D. C. Coccidæ.
1907. SATTERTHWAIT, ALFRED F., U. S. Entom. Lab., Webster Groves, Mo. Calandra.
1922. SCHAFFER, C. H., Box 5, Agric. Coll., Amherst, Mass.
1919. SCHMIEDER, RUDOLF G., 4351 Pechin St., Philadelphia, Pa.
Ch. SCHOENE, W. J., Agric. Exp. Sta., Blacksburg, Va.
1919. SCHWARZ, FRED, 4323 Tennessee Ave., St. Louis, Mo.
1910. SCOTT, E. W., Rockville, Md.
1923. SEAMON, HAROLD L., Canadian Dept. Agric., Dom. Exp. Farm, Lethridge, Alberta.
1922. SELLERS, WENDELL, 90 Pleasant St., Amherst, Mass.
1908. SEVERIN, H. C., State Coll., Brookings, S. D. Orthoptera, Heteroptera.
1907. SHAFER, GEO. D., 321 Melville Ave., Palo Alto, Calif.
1919. SHANNON, RAYMOND C., U. S. Nat. Mus., Washington, D. C.
1922. SHEPARD, HAROLD H., 86 Pleasant St., Amherst, Mass. *Hesperiidæ*.
1917. SHERMAN, FRANKLIN, State Dept. Agric., Raleigh, N. C. Carabidæ, Cicindelidæ, Cerambycidæ.
1911. SHERMAN, JOHN D., JR., 132 Primrose Ave., Mt. Vernon, N. Y.

Ch. Shull, A. Franklin, 520 Linden St., Ann Arbor, Mich. Aphids, Thysanoptera, Whiteflies.
1919. Sibley, Charles K., Dept. Entom., Cornell Univ., Ithaca, N. Y. *Trichoptera*, Leptoceridæ, Neuropteroids.
Ch. Smith, James A., 401 Lenox Ave., Westfield, N. J.
1922. Smith, L. B., U. S. Dept. Agric., Riverton, N. J.
1919. Smith, Marion R., Agric. College, Miss.
1918. Smith, Ralph H., 425 Battery St., San Francisco, Calif.
1914. Smith, Roger C., Agric. Coll., Manhattan, Kans. Neuropteroids, *Chrysopidæ.*
1914. Smulyan, Marcus T., U. S. Bur. Entom., Melrose Highlands, Mass. Tenthredinidæ, *Tenthredella.*
Ch. Smyth, Ellison A., Jr., Va. Poly. Inst., Blacksburg, Va. *Papilio, Sphingidæ.*
1918. Snapp, Oliver I., U. S. Bur. Entom., Fort Valley, Ga. Rhynchophora, Conotrachelus.
1922. Snyder, Thomas E., U. S. Bur. Entom., Washington, D. C. Isoptera.
1914. Spencer, G. J., O. A. College, Guelph, Ont., Canada. Trypetidæ.
1919. Spencer, Herbert, Va. Truck Exp. Sta., Norfolk, Va. Hymenoptera.
1921. Spencer, Robert D., Ashland State Hospital, Ashland, Pa. Diptera.
Ch. Spooner, Charles S., 1436 Seventh St., Charleston, Ill. Hemiptera.
1922. Spuler, Anthony, 611 Michigan Ave., Pullman, Wash. Diptera, Barboridæ.
1910. Stafford, E. W., Agric. College, Miss. Acalyptrate Muscoids.
1917. Stahl, C. F., Care of Citrus Exp. Sta., Riverside, Calif.
1919. Stear, J. R., 406 N. Third St., Harrisburg, Pa. Miridæ.
1917. Stearns, Louis A., Box 155, Leesburg, Va. *Cercopidæ,* Cicadellidæ.
1921. Stevens, O. A., Agricultural College, N. Dak. Bees and Wasps.
1923. Stewart, Morris Albion, Tri Gamma House, Durham, N. H.
1914. Stickney, Fenner S., Indio, Calif. Coleoptera.
1915. Stiles, Charles F., Box 37, Stillwater, Okla.
1922. Stirrett, Geo. M., Purdue Univ., Lafayette, Ind. Halticini.
1913. Stoner, Dayton, 603 Summit St., Iowa City, Iowa. *Scutelleroidea.* Coleoptera.
1912. Strickland, E. H., The University, Edmonton, Alberta.
1917. Sullivan, K. C., Horticulture Bldg., Columbia, Mo.
Ch. Summers, H. E., 712 Edison St., Los Angeles, Calif.
1908. Summers, John N., 964 Main St., Melrose Highlands, Mass.
1921. Sweet, Georgina, The University, Melbourne, Australia. Arachnida, Insects.
1920. Swezey, Otto H., H. S. P. A. Exp. Sta., Honolulu, Hawaii. Lepidoptera, Coleoptera, Homoptera.
1921. Swift, F. R., Corcoran Manor, Mt. Vernon, N. Y. Coleoptera, Diptera, Lepidoptera.
1922. Swingle, Homer S., Sta. F, Columbus, Ohio. Homoptera.
1921. Takahashi, Ryoichi, Dept. Agric., Govt. Research Inst., Taihoku, Formosa, Japan. Aphididæ.
1913. Talbert, Thomas Jesse, Whitten Hall, Columbia, Mo.
Ch. Tanquary, M. C., Agric. Exp. Sta., College Station, Texas.

1922. Taylor, Leland H., Dept. Zoology, W. Va. Univ., Morgantown, W. Va. *Chrysididæ*, Vespoidea.
1922. Teranishi, Cho, No. 12, Nagi, Shirokita-mura, Higashinari-gun, Osaka, Japan. Scoliidæ, Formicidæ.
1921. Thomas, C. A., 120 Broad St., Kennett Square, Chester Co., Pa. Aphididæ, Hymenopterous parasites of same.
1915. Thomas, F. L., Box 24, Agric. Exp. Sta., Auburn, Ala.
1909. Thomas, W. A., Bur. Entom., Chadbourn, N. C.
1919. Thompson, Benj. G., 600 Twenty-sixth St., Sacramento, Calif.
1910. Thompson, W. R., European Parasite Lab., Le Mt., Fenouillet, Hyeres, Var. France. Parasitic Insects.
1922. Thornton, Clarence P., R. F. D. No. 2, Amherst, Mass.
1922. Tietz, Harrison M., 10326 118th St., Richmond Hill, L. I., New York. *Lepidoptera.*
1920. Tillyard, R. J., Cawthron Inst., Nelson, New Zealand. Odonata, Neuropteroids.
1911. Timberlake, P. H., H. S. P. A. Exp. Sta., Honolulu, Hawaii. *Encyrtidæ*, Syrphidæ, *Coccinellidæ.*
Ch. Titus, E. G., 215 S. 3rd East, Salt Lake City, Utah. Megachilidæ, *Osmiinæ.*
1913. Tothill, John D., Fredericton, N. B., Canada. Tachinidæ.
1921. Townsend, M. T., 301 N. H. Bldg., Urbana, Ill. Ecology.
1917. Treherne, R. C., Entom. Branch, Dept. Agric., Ottawa, Canada.
Ch. Troop, James, Purdue Univ., Lafayette, Ind.
1914. Tulloch, Bruce, Care of Messrs. Cox & Co., 16 Charing Cross, S. W., London.
1907. Turner, Charles H., Sumner High School, St. Louis, Mo.
1918. Turner, Wm. B., 600 26th St., Sacramento, Calif. Elateridæ.
1908. Turner, William F., Thomasville, Ga. Heteroptera.
1920. Uichanco, L. B., College of Agric., Los Banos Coll., Laguna, Philippine Islands. *Thysanoptera, Psyllidæ,* Aphididæ.
1917. Urich, F. W., 107 Frederick St., Port-of-Spain, Trinidad, British West Indies.
1922. Vance, Arlo M., U. S. Entom. Lab., Charlottesville, Va.
Ch. Van Dine, D. L., Box 113, State College, Pa.
1917. Van Duzee, Millard C., 12 Abbotsford Place, Buffalo, N. Y. Dolichopodidæ.
1918. Van Zwaluwenburg, R. H., Care of United Sugar Co's., Los Mochis, Sinaloa, Mexico. Elateridæ.
Ch. Vickery, R. A., 10 Court St., Arlington, Mass. Aphididæ.
Ch. Viereck, H. L., U. S. Biological Survey, Washington, D. C. Andrena, Odontophotopsis.
1913. Vorhies, Chas. T., University Sta., Tucson, Ariz.
1915. Wade, Joe S., Bur. Entom., Washington, D. C. Scarabaeidæ.
1921. Wadley, F. M., 126 S. Minneapolis Ave., Wichita, Kansas. Aphids, Hemiptera.
1918. Wainwright, Colbran J., Daylesfond, Handsworth Wood, Birmingham, England. *Tachinidæ.*

1922. Wakeland, Claude, Entomological Substation, Parma, Idaho.
1922. Walkden, Herbert H., 126 S. Minneapolis Ave., Wichita, Kansas.
1917. Wallace, Frank N., State Entomologist, Indianapolis, Ind.
1911. Wallis, J. B., School Board Office, Winnipeg, Canada. Coleoptera; *Haliplidæ, Gyrinidæ Agabus, Coelambus.*
1917. Walton, W. R., Room 5, Bur. Entom., Washington, D. C. Cereal and Forage Insects.
Ch. Washburn, F. L., Exp. Sta., St. Anthony Park, Minn.
1913. Watson, J. R., Agric. Exp. Sta., Gainesville, Fla. *Thysanoptera.*
1921. Watt, Morris N., St. John's Hill, Wanganui, New Zealand. Lepidoptera, Diptera, Hymenoptera.
1916. Webber, R. T., 17 E. Highland Ave., Melrose Highlands, Mass. Tachinidæ.
1920. Webster, Milton F., 121 Glenwood St., Malden, Mass.
Ch. Webster, R. L., Agricultural College, N. Dak.
Ch. Weed, Clarence M., State Normal School, Lowell, Mass.
1917. Weese, A. O., 1321 W. Wood St., Decatur, Ill. Ecology.
1918. Wehrle, L. P., Renwick Heights, Ithaca, New York.
1917. Weigel, Charles A., U. S. Bur. Entom., Washington, D. C. Insects of Ornamentals.
1913. Weiss, Harry B., 19 No. 7th Ave., Highland Park, New Brunswick, N. J. Buprestidæ.
1907. Weld, Lewis H., U. S. Nat. Mus., Washington, D. C. *Cynipidæ.*
Ch. Weldon, Geo. P., Chaffey Jr. College Agric., Ontario, Calif. Thrips.
1921. Wellhouse, W. H., Agric. Coll., Ames, Iowa.
1919. Wells, B. W., State College, Raleigh, N. C. *Insect Galls.*
1912. Wells, M. M., 1177 E. 55th St., Chicago, Ill.
1920. Wells, R. W., Box 208, Dallas, Texas. Insects affecting health of animals.
1920. Wendler-Funaro, Karl H., Cornell Univ., Ithaca, N. Y.
1921. West, Luther S., Dept. Entom., Cornell Univ., Ithaca, N. Y. *Tachinidæ,* Dexiidæ.
1918. Whedon, Arthur D., 525 So. High St., West Chester, Pa. Odonata.
1922. Wheeler, George C., Dept. Zoology, Syracuse Univ., Syracuse, N. Y. Parasitic Hymenoptera, Ants.
1922. Whitehead, Fred E., 1015 Bluemont Ave., Manhattan, Kansas.
1917. Wild, William, 359 Walnut St., East Aurora, N. Y. Microlepidoptera.
1921. Wiley, Grace Olive, 2291 Doswell Ave., St. Paul, Minn. *Nepidæ, Veliidæ, Hydrometridæ, Rheumatobates.*
1914. Williams, R. C., Jr., 4537 Pine St., Philadelphia, Pa. Hesperidæ.
1917. Williams, S. H., State Normal School, Slippery Rock, Pa.
1911. Williamson, Warren, R. F. D. No. 5, Galesburg, Ill.
Ch. Willing, T. N., 417 Clearance Ave., Saskatoon, Saskatchewan, Canada.
Ch. Wilson, H. F., Univ. Wisc., Madison, Wisc.
Ch. Wirtner, M., St. Bonifacius, Pa.
Ch. Woglum, R. S., 831 Consolidated Realty Bldg., Los Angeles, Calif.
1908. Wolcott, R. H., Univ. of Nebraska, Lincoln, Nebr.
1913. Wood, H. P., Box 238, Dallas, Texas.

1914. Wood, W. B., Dept. Agric., Federal Horticultural Board, Washington, D. C.
1913. Woods, William C., Judd Hall, Middletown, Conn. Chrysomelidæ.
1917. Woodworth, C. W., Kiangsu Province, Shanghai, China.
1917. Woodworth, H. E., 2237 Carlton St., Berkeley, Calif. Thysanoptera.
1922. Worthley, Harlan N., Agric. Exp. Sta., Amherst, Mass. Tachinidæ.
Ch. Yothers, W. W., Box 491, Orlando, Fla.
1917. Yuasa, H., Care of Japanische Botschaft, Koningsplatz 4, Berlin, Deutschland. Sawfly larvæ.
1917. Zahrobsky, V. J., 287 Wood St., Wilmerding, Pa.
1921. Zerny, Hans, Wien I, Burgring 7, Austria. Heterocera.
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SOME BRACONIDS PARASITIC ON APHIDS AND THEIR LIFE-HISTORY. (HYM.)*

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The present paper deals with the larval development of some very interesting Hymenopterous parasites of the Aphididæ. Most of the known parasites of these destructive insects belong to the Braconid subfamily Aphidiinæ, the numerous genera of which appear to parasitize aphids almost exclusively. In spite of their abundance, practically nothing has been known previously regarding the structure of the larvæ, although the group has received considerable attention at the hands of economic entomologists on account of its practical importance in the natural control of injurious plant-lice.

The adult Aphidiinæ are small, slender creatures, usually about two mm. long, with delicate, transparent wings. In color, they vary from black through reddish-brown to yellow. The mandibles are triangular, bidentate; the antennæ, filiform, many-segmented; the lateral mesothoracic plate or mesepisternum, very large; the legs are long and slender with very small claws; the abdomen of the female is lanceolate and very flexible; that of the male, short ovate. The wing veins are considerably reduced and exhibit great variation, but there are always two complete basal or median cells.

On account of the greatly scattered literature, a résumé is given of the previous studies on the larval stages and

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development of other parasitic Hymenoptera as well as the Aphidiinæ, including the Chalcidoidea, Proctotrypoidea, Ichneumonoidea, etc.

I wish to express my gratitude to Professor C. T. Brues and Professor W. M. Wheeler for their criticism and encouragement in this work, and also to Doctor Edith M. Patch and Mr. A. B. Gahan for assistance in the identification of the species of the Aphididæ and Aphidiinæ.

LARVAL TYPES.

The types of larva used in the ensuing discussion may be briefly defined as follows:

1. *Hymenopteriform.* This type is fourteen-segmented, apodous, tapering toward the extremities, and having very small head and tail segments. It is common to all species discussed in their mature stage except possibly (a) *Polynema* (here Ganin's ('69) descriptions may be those of younger stages); (b) *Perilampus*, *Orasema*, and *Spalangia*, which have tuberculate hymenopteriform larvæ; and (c) *Archirileya inopinata* Silv. ('20), whose fifth stage with an anal vesicle probably belongs to the next type.

2. *Caudate.* The caudate type possesses an anal segment elongated to form a simple tail usually without appendages or with a globular anal vesicle. The first segment is enlarged into a definite head. The intervening segments are either of the same diameter or decrease slightly toward the tail.

3. *Cyclopoid.* The cyclopoid larva is divided into (a) a large cephalothorax, composed of the head and at least one of the thoracic segments, and (b) a narrow, segmented, tail-like region ending in a dentate or hairy bifurcation. As the name suggests, it is much like the Crustacean in appearance. The enormous head bears long, curved mandibles. This type is found chiefly in the Proctotrypoidea.

4. *Planidium.* The heavily chitinized, motile, ectoparasitic larva, called a planidium, is widest at its thorax; the head is rather rounded with strong mandibles, but the posterior part of the body is attenuated, often ending in two bristle-like appendages. Spines may be present dorsally and ventrally. This type is restricted to the Chalcidoidea.

Some other larval types found among the parasitic Hymenoptera, less widespread but nevertheless striking, are the following:

5. *Embryonic larva.* This larva is composed of a sac-like group of undifferentiated cells and has been found only in a species of *Polynema* of the Chalcidoidea, by Ganin ('69).

6. "*Spindle-shaped.*" This type exhibits a definite head with a prominent ventral prolongation, a tapering body with circular fringes of hairs, and a long tail with basal serrations. The only species found to have this larva is *Polynema bifasciatipenne* Girault ('10).

7. *Eucoilaform.* This kind of Cynipid larva has a bird shaped head without mandibles, a definite thorax with three pairs of unsegmented appendages, and narrow abdominal segments curving dorsally, ending in a tail at right angles to the dorsum. It has been found as the first instar of *Eucoila keilini* Kieff. (Keilin '13).

8. *Agriotypiform.* The mature larva of *Agriotypus armatus* Walk. has been called an agriotypiform larva. The diameters of the segments vary, presenting a very irregular body outline. The mandibles are coarsely serrated. (Klapálek '89).

9. *Chrysidiform.* This type, found in *Chrysis dichroa* Dhlb. (Ferton '05), is characterized by a peculiar caudal segment, the two tips of which are mobile, retractile, and lie bent toward one another when at rest.

CHALCIDOIDEA.

Ganin ('69) gives an account of the larva of an undetermined species of *Polynema*, parasitic on the eggs of a dragon fly, *Agrion virgo.* The embryo leaves the egg when only a "mere flask-shaped sac of cells." After five or six days, this embryonic larva takes on a definite larval form. The head and tail segments are of about the same width as the body segments. The head is square with two thick lateral antennæ and two smaller, anterior, median, very sharply pointed projections. The anal segment bears three pairs of tubercles.

Ayers ('84) in his thesis "On the Development of *Œcanthus niveus* and its Parasite *Teleas*," devotes a small part of his paper to the two earliest larval stages of the parasite which has since been identified as the Chalcidoid *Polynema bifasciati-*

penne Girault ('10). The animal hatches into the yellow yolk-mass of the *Œcanthus* egg. At first, it is composed of head and tail with from five to eight rather indistinct body segments between, each bearing a row of spines about its equator. The head is elongated in front to form a blunt process and, strange to say, has four mandibles (probably the two mandibles, the labrum, and the labium), the posterior anterior ones working at right angles to the lateral ones. The long tail shows on the ventral part of its base some tooth-like projections with a varying number of basal spines. The second stage resembles Ganin's first stage or cyclopoid larva of *Teleas* and Marchal's intermediate larva (Proctotrypoidea), to be described later. The body is rather flat and possesses a prominent head and hooked mandibles. The tail is not posterior but projects ventrally and ends in a "dentate knob." The mouth has a strikingly hooked lower lip which may be bifid, but always remains concave on its upper surface. The antennæ are very noticeable.* Ayers thought there were three or four larval stages but unfortunately did not complete his study.

The Chalcidoid *Ageniaspis* (=*Encyrtus*) *fuscicollis* Dalm. was found by Bugnion ('92), parasitic on the caterpillar of *Hyponomeuta cognatella*. This insect develops polyembryonically, and the multiple embryos form a chain, provided with a membranous covering, such as Marchal ('04) found. About them there is developed an extensive ramification of the tracheæ of the host. The first larval stage found is hymenopteriform, tapering more posteriorly than anteriorly, and bent only slightly. The chitin is free posteriorly, forming "une sorte de capuchon caudal." This may represent one of the two following conditions, (1) either the caste skin adheres to the anal segment as Silvestri ('19, a and b; '20) has found recently to be of common occurrence among Chalcidoids; or (2), the process of molting has begun, commencing at the tail and proceding forward, as de la Baume-Pluvinel ('15) found to be the case with the Braconid *Adelura gahani*. His figure resembles more closely the second condition, but the first is of greater distribution.

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* McColloch ('15) found a larval stage of *Eumicrasoma benefica* Gahan, parasitic on the chinch bug, to be similar to this larva.

Embleton's ('04) *Comys infelix* is related to the *Ageniaspis* of Bugnion's paper, but has different habits. It is parasitic on a Coccid, *Lecanium hemisphæricum* var. *filicum*. There is a great disproportion of sexes, about one thousand females to one male. After ovipositing in the thoracic region of the host, the female applies its mouth to the wound. This habit of feeding from the puncture, made by the ovipositor, is characteristic of many Chalcids. The first larva of *Comys* has its thickest portion in the middle and possesses two tail-like appendages. The second larval stage is marked by an increase in diameter and the disappearance of the tails. The third stage, of the usual hymenopteriform shape, has a queer modification of the tracheal system. From each of the four spiracles "there is a double tracheal tube running out into the host's body; these two branches become subdivided and ramify in the host's tissue." Whether these ramifications originate from the host or parasite was not determined.

Riley ('07) has reviewed Silvestri's work ('06) on *Litomastix*, which oviposits in the egg of a species of *Plusia*. Two types of larvæ develop from the one egg—about one thousand normal and about one hundred "asexual larvæ." The "asexual larvæ" with their very strong mandibles are probably useful in breaking down the tissues of the host for the consumption of their relatives, but they soon degenerate, never attaining the adult state. He calls this phenomenon "precocious development of caste."

Wheeler ('07) discovered a new type of Chalcidoid larva in the genus *Orasema*, parasitic on Formicidæ. The young larva or planidium partly encircles the neck of the ant semi-pupa. In 1912, Smith found a planidium of *Perilampus hyalinus* Say, and in 1917, another planidium of a parasite on *Chrysopa*, called *Perilampus chrysopæ* Crawford. Thompson ('15) discovered planidium larvæ as secondary parasites of a Noctuid. Recently Ford ('22) records a planidium larva of *Perilampus* sp., parasitic on a Locustid, *Conocephalus fasciatus* De Geer. *Spalangia muscidarum* Richardson ('13), described by that author as ectoparasitic on house-fly pupæ, has a first stage larva which he considers as belonging to the planidium type.

Packard ('16) published a study of three Chalcidoids parasitic on *Mayetiola destructor* Say, the Hessian fly. They are external parasites, with five larval stages and a naked pupal

stage. The first, *Eupelmus allynii* French, has a curious egg usually with a stalk at each end "fastened to the inner surface of the puparium by a little net-like structure." The mandibles are the same in all stages except for a successive increase in size. The mature larva has characteristic hairs on the body, a labrum with six points, and a bristle near the base of each mandible. The second, *Merisus destructor* Say, has an elongate, kidney-shaped egg, very similar to that of *Homoporus* (= *Micromelus*) *subapterus* Riley, the third Chalcidoid studied. Both have two pairs of tubercles on the larval head. The mandibles of the later stages are alike in being rather straight and pointed for a Chalcidoid, but that *H. subapterus* is more suddenly sharpened.

Aphycus lounsburyi How. (Smith and Compere '20), an Encyrtid, is parasitic on the black scale, *Saissetia oleæ* Bern. I quote their description of the oviposition which was observed on a scale glued to the lower side of a glass slide. The parasite backs up to the scale and inserts the ovipositor under the rim, "when the egg is forced from the uterus into the ovipositor; it is compressed to a long cylindrical form so as to pass through the channel in the long, slender ovipositor. The egg is hardly recognizable as it passes through the ovipositor, for so rapid and even is the movement that it looks more like a flow of quicksilver than the passage of an egg. The forepart of the egg, which still retains its cylindrical form, acts like a probe to penetrate some distance beyond the tip of the ovipositor into the body of the scale. Suddenly the liquid contents of the egg rush forward, inflating the anterior portion, * * * *. The hind section of the egg remains tube-shaped after the contents have rushed forward. The parasite then withdraws the ovipositor, leaving the tube molded in position, supporting the bulb or main body at one end, and the other end of the tube projecting through the integument of the host into the outer air." After hatching, the larva is suspended at its posterior end by the stem which protrudes through the scale shell and probably "functions as an air line" for the respiration of the insect. It remains attached to this stem until the third stage, when the tracheæ become well developed.*

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* Since this paper was written, studies on Chalcid hyperparasites of aphids have been published by Haviland (Quart. Jour. Micr. Sc., N. S., '20, LXV, no. 257; '22, LXVI, 321-338.)

PROCTOTRYPOIDEA.

The life-histories of the Proctotrypoids have been studied chiefly by Ganin ('69), Kulagin ('92, '97), and Marchal ('06). Marchal's work on "Les Platygasters" brings to date the work of the others and presents the entire embryological development in detail.

Platygastrinæ, such as *Synopeas rhanis* Walk., have a long stalked egg and a very characteristic cyclopoid larva. It has a large head and a narrow tail, ending in two appendages. The head bears extremely long, curved, sharp mandibles, two-jointed antennæ, a strongly chitinized labrum with teeth, and a ligula (labium?) with a smaller series of teeth. The insect hibernates in the "intermediate stage." The head and tail characters of the first stage persist, but the body is large and rounded. The "secondary" larva has no visible segmentation. The mandibles, minute, bidentate, are situated in the mouth, which has muscles to open and close it and is probably adapted to sucking. The third stage, not separated by a molt as Ganin thought, has small, sharp mandibles and is clearly segmented.

Trichacis remulus Walk. is interesting as an example of those Proctotrypoidea which lay their eggs in the nerve chain of their host, where they induce the formation of gall-like structures.

Pemberton and Willard ('18 b) describe a Proctotrypoid, *Galesus* (=*Diapria*) *silvestri* Kieff., which may live either as a primary or as a secondary parasite of the fruit-fly pupa. This species has a large head, curved mandibles, very prominent antennæ, and a bidentate labrum. It passes through three or four similar larval stages, the others having small heads and simple bodies.

ICHNEUMONIDÆ.

Lyonnet ('32) described and figured the mature larva of *Ophion luteus* L.

Ratzeburg ('44) decided that the Ichneumonidæ had four and five larval stages. *Anomalon* (=*Exochilum*) *circumflexum* L. has a first instar of the caudate type, but with a very accentuated tail. In the second and third stages, the larva becomes stouter, and this tail gradually disappears until it is completely absent in the fourth stage, small-headed hymenopteriform larva.

Paniscus (=*Parabates*) *virgatus* Fourc., parasitic on *Mamestra pisa*, according to Newport ('52), deposits a black egg with a stalk, the end of which is imbedded in the caterpillar's skin. The egg cracks longitudinally. The larva pokes its head out, bites a hole in the host's skin and begins to feed. As it increases in size, it gradually emerges but remains attached to the egg shell. The three exuviæ of the larva form a covering for the posterior part of the body. Newport found the larva of *Ichneumon atropos* Curtis between the heart and stomach of the pupa of *Sphinx ligustri*. It has lateral and ventral tubercles on all the body segments. Ventral tubercles have not been discovered elsewhere on Ichneumonid larvæ. The anal segment is produced into two spines.

Riley ('88) made a study of *Thalessa atrata* Fab. and *Thalessa lunator* Fab., which lay their eggs in burrows of *Tremex columba* L. He describes a hymenopteriform larva of *lunator* and figures a lateral view of the head (which, by the way, is upside down). Bugnion ('04) found the egg of *Rhyssa persuasoria* (a related genus) with an extremely long stem, the whole measuring 12 to 13.5 mm.

Limnerium (=*Campoplex*) *validum* Cress., a parasite of the brown-tail moth, *Euproctis chrysorrhœa* L., according to Timberlake ('12), has three larval stages. The first has an enormous head and a long tail; the mouth is characterized by a circular rim. In his figure there are ventral projections on some of the middle segments. The second stage has a cylindrical body of thirteen segments, with a funnel-shaped mouth cavity. The third stage is of the usual hymenopteriform type, but with thirteen segments and complicated facial characters.

BRACONIDÆ.

Early mention of a Braconid larva was made by Ratzeburg ('44), who described the larval stages of *Microgaster nemorum* Hart. (now *Apanteles fulvipes* Hal.). The first instar is a twelve-segmented, simple, caudate larva. The second stage possesses a double pair of silk glands and an anal vesicle. The other three stages show a gradual change to the fifth stage hymenopteriform larva.

Seurat ('99) in a work on the "Hyménoptères entomophages" discusses the growth of the externally living Braconid,

Doryctes gallicus Rein., parasitic on *Callidium sanguineum* L. Ten to fifteen *Doryctes* larvæ are found on a single host with their mouths applied to cuts made in the chitin. The mature larva has the usual thirteen segments and a head, which bears the mouth, labrum, strong mandibles, maxillæ with palpi, labium, and orifice of the silk glands. On its anterior dorsal surface is a pair of small antennæ. The body is covered with spines. He distinguishes six larval stages.

Keilin and Picardo ('13) published an account of *Diachasma crawfordi* Keil., a Braconid parasitic on the fruit-fly, *Anastrepha striata* Schm. A curious fact about its larva is that, since the dorsal surface is concave, it appears to be inverted. The nervous system and the two Malpighian tubules seem to be dorsal to the stomach; the salivary glands and gonads just under them, overlapping the ventral part of the stomach. Dorsally, the median heart is visible. This superficial semblance of inversion is heightened by appendages (really dorsal) on the first and third thoracic segments. The pair on the first thoracic segment are large and rounded with three papillæ on the apex of each; the pair on the third thoracic segment are very much smaller, but have sharply pointed tips. Laboulbène ('58) found the larva of an Ichneumonid, *Pimpla* (= *Polysphincta*) *fairmairei* Lab. which has "pseudopodia" on each segment of its convex dorsal surface. They are single protuberances with a ring of hairs on the tip. The *Diachasma* larva is composed of a head and twelve or thirteen segments. The mouth opening is located on the anterior dorsal surface. The region of the clypeus, distinctly separated from the so-called "pleural plates," is strongly chitinized and probably corresponds to the labium of the Aphidiinæ. The mandibles are large and curved as in other Opiinæ which have been studied. He found antennæ on the clypeus, and near them a pair of palpoid organs. Another pair is situated at a short distance ventrally, on the pleural plates. The mature larva is covered with spines. The mandibles are small, far apart, and weakly chitinized. The labrum has several pairs of sense organs in the form of hairs and single or double chitinous rings. Otherwise the face is much like that of a mature Aphidiine larva.

De la Baume-Pluvinel ('15) related the facts pertaining to the growth of another Braconid, *Adelura gahani* Baume,

parasitic on a Dipteron. The first instar has a large, distinct head and tail, with twelve segments between. The animal is concave dorsally and like *Diachasma crawfordi* appears to be inverted. It has well-developed organs including tracheæ. The antennæ and mandibles are dorsal as well as the paired tufts of hair on the margin of each dorsal segment. The second stage is marked by an unchitinized head, a slight prolongation of the anal segment, three prominent pairs of papillæ, small mandibles, and by the absence of tracheæ. The third stage is covered with teeth, but these are not described in sufficient detail for comparison with those found in the Aphidiinæ. The head of this instar is strongly chitinized, divided into plates, and covered with hairs and circular papillæ. Tracheæ are present.

Thersilochus conotracheli Riley develops in the plum curculio (Cushman '16). The first larval stage, very much like that of *Limnerium validum* Cress., has thirteen segments and is characterized by a tail and a large head with "heavily chitinized, acute, curved mandibles, and very delicate labrum, maxillæ, and labium." The second stage has lost the prominent head, tail, and strong mouth-parts. The third instar is separable by its stouter size and wider head (0.07 mm. wider). The fourth is curved, tapering toward the ends like most parasitic larvæ, i. e., hymenopteriform. The fifth is very similar, but larger and more heavily chitinized.

From the work done on the Mediterranean fruit-fly in Hawaii by Back and Pemberton ('18) and Pemberton and Willard ('18, a and b), the life-histories of several parasites are recounted. The Opiine, *Diachasma tryoni* Cam., has four larval stages. It hatches with a large, heavily chitinized head, long sickle-shaped mandibles, two palpi and two teeth on the labium. Ventrally, behind the head, are two bag-like appendages, which seem to arise from the suture between the head and the first thoracic segment. They may be the same as the prothoracic legs which Keilin found on *D. crawfordi.* The body of the second stage larva is composed of thirteen segments and a small, poorly differentiated head with soft mandibles. The third stage is much like the second. Except for the head, the fourth is covered with very attenuate, acuate spines. The mandibles are more pointed. There are present also the

maxillæ, two pairs of palpi, and a chitinized labrum with its palpi (probably the antennæ).

Willard has recently published ('20) the results of parasitism on the melon-fly, *Bactrocera cucurbitæ* Coq. by another Opiine, *Opius fletcheri* Silvestri. This has a large-headed, strong-mandibled larva, like the other Opiinæ, with two teeth on the labium and appendages on the second segment. The remaining three larval stages are hymenopteriform; the mandibles of the second and third stages are very slightly chitinized, for the larva lives then on the soft parts of the host. The head of the mature instar has characteristic hairs and papillæ. The body spines are like those of *D. tryoni* in shape, but slightly larger and thicker.

In 1918, Muesebeck grew a Braconid, *Meteorus versicolor* Wesmael, on larvæ of the brown-tail moth. The first stage, a caudate larva, has a long anal appendage and "a large, brown, heavily chitinized head capsule, containing a pair of strong, curved mandibles." The head of the second stage is not chitinized, and the anal appendage is smaller. In the third, the mandibles are chitinized, and the anal appendage is very short.

Another parasite of the brown-tail moth, a Braconid, *Apanteles lacteicolor* Viereck, is found in the posterior half of the host's body, where, in its first stage, it passes the winter. Dorsally, a transverse row of short, posteriorly projecting spines is present on each of the last nine segments. The mandibles are very heavy and pointed. The larva has a tail and the caudal swelling or "bladder-like structure" known as the anal vesicle. Ratzeburg ('44), Seurat ('99), and Kulagin ('92), have studied this organ; and Weissenberg ('08) summarized their work and determined it to be an evaginated portion of the intestine. The tracheal system in *Apanteles glomeratus* Latr., the species studied by Weissenberg, is not formed until the last endoparasitic stage, when the vesicle begins to be reinvaginated, hence it is possible that its function is respiratory, but he considers that, as an excretory organ, it is of more importance. In the second stage larva of *A. lacteicolor*, it is much enlarged, but the tail is small; the unchitinized mandibles are bidentate. The third instar has pectinate mandibles. Tracheæ are hithertofore not present. The vesicle disappears.

APHIDIINÆ.

According to De Geer (1771), the first observers to notice internal aphid parasites were Swammerdam (1737) and Leeuwenhoek (1695, 1700). De Geer observed that the essential internal organs of the host are not touched at first by the parasite, and that the dead aphid is attached to the substratum, not by the legs, but by a quickly hardening, sticky substance. He also depicts the mature larva, its face, and the curved pupa in tiny figures.

An interesting footnote by Haliday ('34, p. 98) in his "Classification of Parasitic Hymenoptera" describes the habits of *Aphidius rosæ* Hal.

I have been able to find only two papers dealing with studies made on the larval stages of the Aphidiinæ. Seurat ('99) made an incomplete life-history study of a species of *Aphidius*, dwelling chiefly on the anatomy and tracheal system of the larva. His figure illustrating the latter resembles a late stage secondary Chalcid parasite such as *Lygocerus*. I have not yet found any tracheæ in Aphidiines. His diagram of the anatomy will be discussed later. The second study is that of Timberlake ('10) which is mentioned in another section of this paper.

THE LIFE-HISTORY OF THE APHIDIINÆ.

The following species were used in this study:

TABLE 1.

Parasite	Aphid Hosts	Plant
Aphidius ribis Hal	*Macrosiphum* sp	Jerusalem Artichoke
Aphidius phorodontis Ash	*Myzus persicæ*	Radish
Lysiphlebus testaceipes Cress.	*Macrosiphum tanaceti*	Tansy
Praon simulans Prov	*Myzus persicæ*	Radish
Ephedrus incompletus Prov	*Aphis pseudobrassicæ*	Radish
	Myzus persicæ	Radish
Diæretus rapæ Curtis	*Myzus persicæ*	Cabbage

MATING.

Aphidiines which have never been at liberty will mate freely in petri dishes or even in small glass vials. Copulation lasts from 30 to 60 seconds. Withington ('08) found that it averaged 52 seconds for *Lysiphlebus* sp. (=*Ephedrus*).

OVIPOSITION.

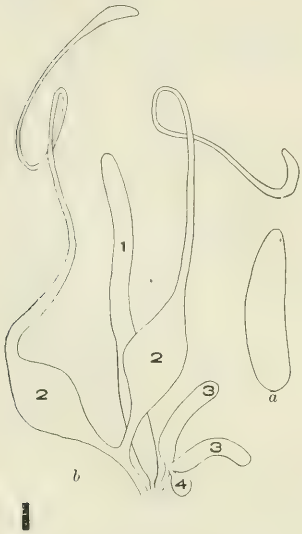
Oviposition generally occurs during the morning from eight o'clock until one. After that time, the females stand scattered about, usually on the under side of the leaves or in inconspicuous crevices of the stems.

During the egg laying period, when in the vicinity of the aphid, the parasite begins to vibrate the antennæ excitedly and stealthily approaches from behind. The wings are outspread and the abdomen bent under the thorax so that the point projects in front of its head.* In this position, it makes a sudden lunge at the aphid, sometimes, though not always, tapping the animal first with its antennæ. In order to hold the ovipositor in place long enough to lay the egg, it is forced to beat its wings frantically or else it would lose its balance in this acrobatic position. The whole process lasts only a few seconds. The aim of the ovipositor is not sure, for although the abdomen is probably the most advantageous spot, the thorax or a leg is sometimes punctured. I have witnessed attempts to oviposit in bits of debris in the neighborhood of aphids and even in the aphid eggs at about the natural height of the aphid abdomen. Likewise, the instinct of the insect to lay eggs in unparasitized hosts, as sometimes is claimed, is not exact. Especially, if the supply of aphids is limited, the same female, in the course of her rounds, has been observed to return three and four times to oviposit in the same aphid. Although it may come back, the parasite leaves the aphid immediately after egg laying and never feeds at the puncture.

* Hunter ('09) Illustration, p. 144, fig. 4.

REPRODUCTIVE SYSTEM.

The egg is colorless, elliptical, narrower at one end than at the other, with its long axis slightly curved. It is rather transparent and has no stalk. In two species its dimensions are as follows: *Aphidius phorodontis* Ash., length, 0.125 mm.; greatest width, 0.031 mm.; *Ephedrus incompletus* Prov., length, 0.148 mm., width, 0.038 mm. (Fig. 1 a).



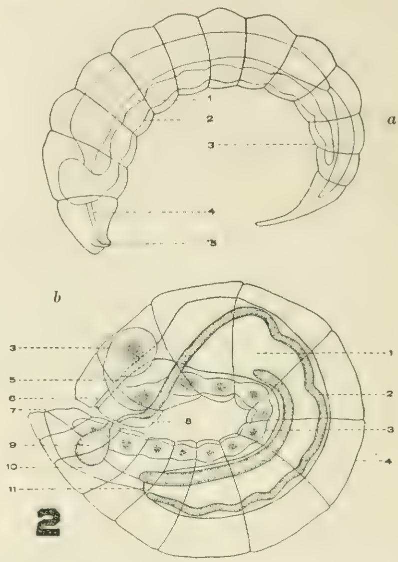


Fig. 1. *Ephedrus incompletus* Prov. *a*, Egg; *b*, Reproductive system; 1, Alkaline gland; 2, Ovaries; 3 Poison glands; 4, Receptacle.

Fig. 2. *Aphidius phorodontis* Ash. *a*, Second stage larva; 1, Stomach; 2, Nervous system; 3, Rudimentary intestine; 4, Œsophagus; 5, Mandible; *b*, Fourth stage larva; 1, Stomach; 2, Silk gland; 3, Nervous system; 4, Malpighian tubule; 5, Œsophagus; 6, Mouth; 7, Anus; 8, Silk gland orifice; 9, Gonad; 10, Intestine; 11, Blind extremity of the stomach.

The female organs of *Aphidius phorodontis* Ash. and *Ephedrus incompletus* Prov. were examined and found to be similar. As those of the second species were examined in freshly killed material, the following description is based on *Ephedrus* rather than *Aphidius* which was represented only by specimens in alcohol.

The eggs are packed very closely in the two ovaries. The extremities of the ovarioles are coiled in the fatty tissue about the stomach. The end is thickened, but soon narrows down

to a long tube which, in turn, enlarges into a bulb. The narrow tube is four to five times as long as the bulb. The short ducts of the two ovarioles join in the oviduct, which soon meets the ovipositor. Also leading to the ovipositor are the poison gland and the alkaline gland. The two poison glands are shorter than the bulb and squared at their ends. At the point where they come together in a duct, there is a round receptacle. The single alkaline gland is slightly thicker than the poison gland and three times as long. (Fig. 1, b). It is characterized by its contents, which consist of globular, rather evenly packed masses.

Pemberton ('18 b, p. 437) has depicted a Braconid reproductive system, that of *Diachasma tryoni*, which has three parts—ovaries, poison glands, and alkaline gland. However, each ovary consists of two tubules which taper more gradually to the tips; the poison glands are very long and sinuous, large at the base, where they enter the receptacle, and attenuated at the ends; the alkaline gland is more or less leaf-shaped rather than tubular.

Larval Stages of *Aphidius phorodontis* Fitch.

Four or five days after oviposition, small larvæ were found in *Myzus persicæ*, varying in length from 0.376 to 0.481 mm., of white color, with the mandibles brown at the tips. There are thirteen segments. Probably the narrow, attenuated tail, which is as long as the three preceding segments, is composed of two, making, in reality, fourteen. The head, about as long as the tail, tapers to a truncated extremity where the mouth is situated. The two mandibles which protrude anteriorly, are long, very sharply pointed and slightly curved inward. The animal seems to be smooth in this stage, but in the second stage (length 0.496–0.706 mm.) the tail has a few scattered spines, and there are occasional spines visible on the dorsum. (Fig. 2 a). The tail is somewhat shorter and the head smaller with inconspicuous antennal palpi. The mandibles are of the same shape and size as the first stage, although they seem smaller because of the increase in the size of the insect.

The third stage is characterized by the loss of the tail. Although the larva was previously curved ventrally, the curvature now becomes exaggerated so that it is unable to straighten out. Since the curve varies, the measurements

of length can be only approximate. The length of this stage in its curved position is from 0.466 mm. to 0.646 mm. The anal segment has a blunt point, but no definite elongation. The shape of the body has changed. Segments two to seven are of about the same diameter; the following ones taper only gradually. The width of the anal segment, at its base, is about one-half that of the second segment.

The fourth stage (approximate length 0.676–1.022 mm.) is similar, but larger, thicker, with a comparatively smaller head and posterior segment. (Fig. 2 b). I have been unable to find the mandibles of the third and fourth stages.

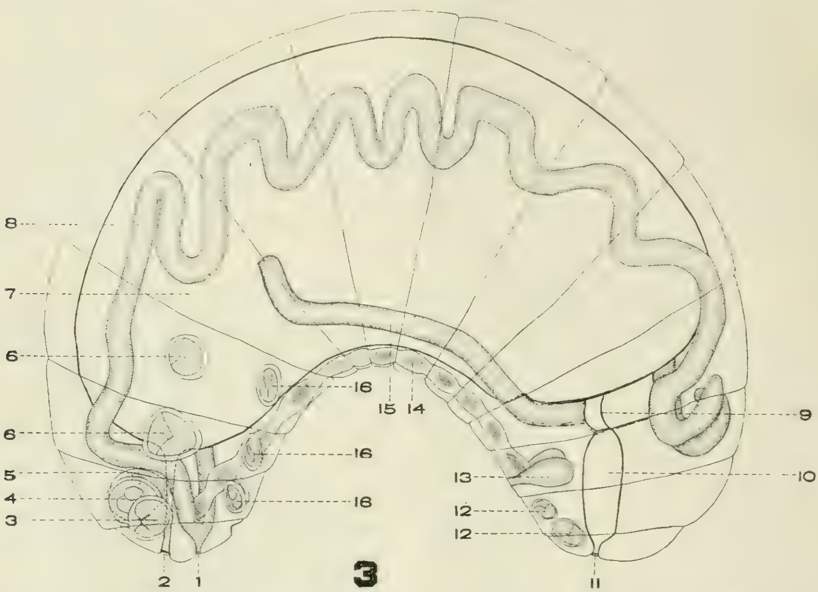


Fig. 3. *Aphidius ribis* Hal., mature larva; 1, Silk gland orifice; 2, Mouth; 3, Imaginal disc of the eye; 4, Imaginal disc of the antenna; 5, Supraœsophageal ganglion; 6, Imaginal discs of the wings; 7, Stomach; 8, Silk gland; 9, Ileum; 10, Rectum; 11, Anus; 12, Imaginal discs of the genetalia; 13, Gonad; 14, Nervous system; 15 Malpighian tubule; 16, Imaginal discs of the legs.

The fifth stage or mature larva (approximate length 1.082–1.503 mm.) is white, with brown-tinted stomach cavity and white spots under the chitin, probably groups of adipose tissue. The animal, composed of fourteen definite segments, is of a different shape from the preceding. (*cf.* lateral view of *A. ribis*, fig. 3). It is widest at the middle and tapers toward

the head and anal segment. The last segment is blunter than the head. The dorsum is thickly set with reclinate, short spines which fade out toward the ventral portion. The ventrum is smooth except on the head, where the spines are like those of the back, but with a tendency to point forward. The head, similar to that of *Diæretus rapæ* Curtis, is about as long as the second segment or the thirteenth and fourteenth together.

The process of molting was not observed. Consequently, the determination of the five stages has been made by appearance and by differences in size.

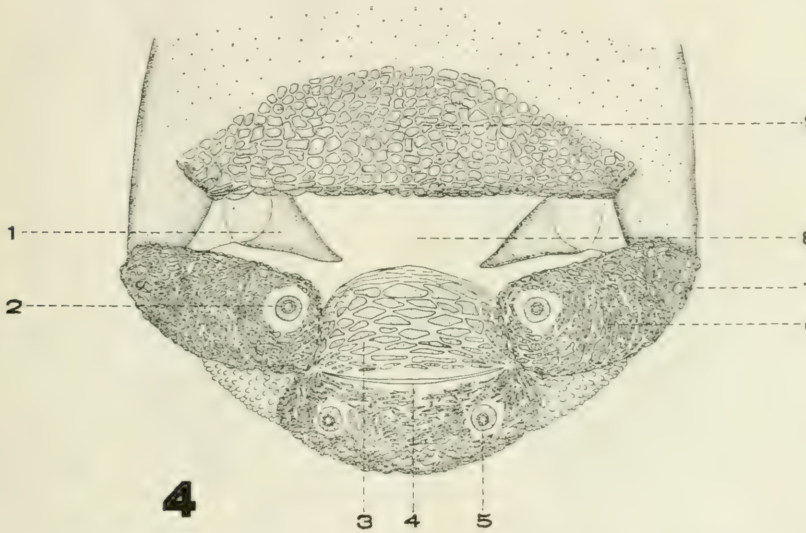


Fig. 4. *Diæretus rapæ* Curtis, anterior view of the head. 1, Mandible; 2, Maxillary palpus; 3, Labium; 4, Silk gland orifice; 5, Labial palpus; 6, Maxilla; 7, Papilla on the maxilla; 8, Mouth opening; 9, Labrum.

Mature Larva of *Diæretus rapæ* Curtis.

The shape is like that of other mature Aphidiine larvæ—hymenopteriform, wide at the middle and tapering toward the two ends with the posterior end rounder than the anterior. The body is covered with blunt spines which are reduced to simple folds ventrally, but dorsally on segments three to seven, the spines become very sharp, reclinate, and are arranged in rows.

The mouth opening, which is anterior in position, is long, rectangular in shape (Fig. 4). At its short lateral ends, extend-

ing only a quarter of the distance across the cavity, are the small mandibles, with heavily chitinized tips. The labrum is differentiated from the remaining smooth dorsal part of the head segment by its covering of very blunt spines, or rather, protruding, truncate, chitinous plates, bearing occasional tiny, needle-pointed hairs. Below the mouth, in the center, is the labium, on each side of which and under the mandible is a maxilla. The labium is circular in shape, and divided in halves by the slit-like orifice of the silk glands. The upper half

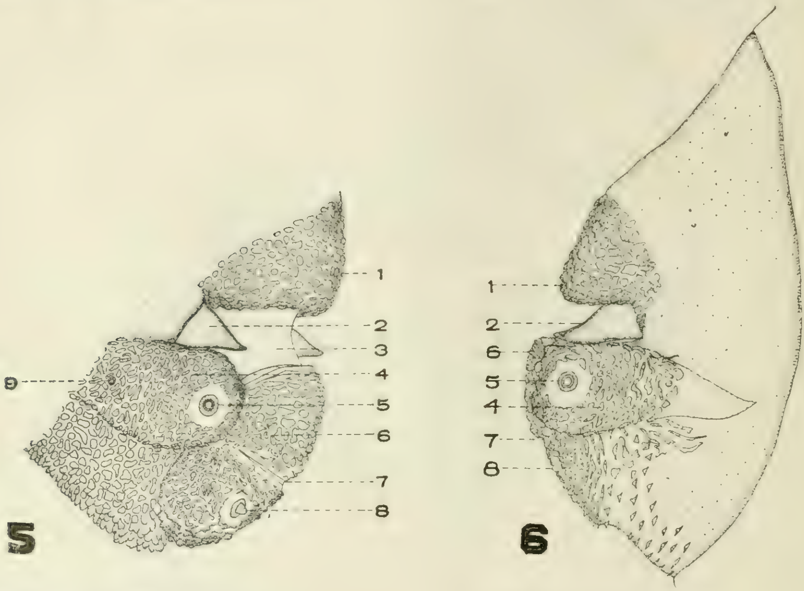


Fig. 5. *Diæretus rapæ* Curtis, anterior lateral view of the head.
Fig. 6. *Aphidius ribis* Hal., lateral view of the head. 1, Labrum; 2, Mandible; 3, Mouth opening; 4, Maxilla; 5, Maxillary palpus; 6, Labium; 7, Silk gland orifice; 8, Labial palpus; 9, Papilla on the maxilla.

is covered with large chitinous plates which degenerate into folds at the mouth and at the gland opening; the lower half, more oval and bearing two palpi, has more rounded plates, which become spine-like ridges ventrally. The maxilla is egg-shaped with the broad end toward the mouth, and is clothed by irregular narrow plates which form concentric circles about the maxillary palpus. This palpus, of the same size as the labial palpus, is situated near the mouth opening. It is composed of a short peg-like projection set in a heavily chitinized circle.

On the central lateral portion of the maxilla is a small palpus-like papilla about one-fourth the size of this large one. Beneath the labium, the surface is very thickly set with heavy spines, although not sharp like the dorsal spines of the animal.

The head of *Aphidius ribis* Hal. is very similar, (Fig. 6). The mandibles are of the same shape, but a little longer. The plates of the maxilla do not extend so far back, and the small papilla seems to be absent.

First Stage Larva of *Ephedrus incompletus* Prov.

Length 0.524 mm., white with ferrugineous mandibles. Head large, broadly rounded, almost as long as the three following segments which are the widest; the rest of the body tapering to the anal segment, which is about as long as the head and composed of a slightly curved tail with successive rows of hairs, and two shorter, hairless, ventral projections. Around the equator of each body segment is a fringe of hairs, which seem to be connected at their bases so as to form a saw-edged band, whose teeth become blunter ventrally except on the last two segments before the tail, where they are sharp all the way round. The body is curved, but can be straightened out, a fact which is not true for the later stages. In the anterior ventral part of the head is the broad, oval mouth opening, across which the two small, short mandibles operate. Anterior to the mouth are two prominent palpiform appendages, the antennæ. Ventrally, near the suture of the second segment, are two pairs of protuberances, probably sensory papillæ.

Timberlake ('10) has described the first stage larva of *Praon simulans* Prov. which reminds one of *E. incompletus*. The head, according to his figure, is rounded, but comes to a point on its ventral anterior portion, in front of the small mandibles. The first three segments are apparently without hairs, but he describes the "metathoracic and first to ninth abdominal segments provided with a comb of comparatively coarse bristles along their posterior margins." The tail has a few bristles at its apex and the two smaller ventral appendages.

He also figures and describes briefly the first stage larva of *Aphidius rosæ* Hal. (?) which is like *A. phorodontis* except for the "projecting lobes" on each side of the ventral posterior margin of the head, and a slight irregularity in the diameters of segments two to seven.

DIGESTIVE SYSTEM.

The first and second stage larvæ of *Aphidius phorodontis* have a long, narrow stomach, widest in the fourth and tapering to a point in the tenth segment. (Fig. 2 a). Thence into the tail there extends a narrow mass of cells, tapering at both ends, and representing the rudiments of the posterior intestine. The silk glands are not yet formed.

In the third stage, the stomach is of a similar shape, but wider throughout, as is also the body of the animal. The posterior intestine is formed and the ileum and rectum are becoming differentiated in outline.

In the fourth stage there is an increase in size of all the organs except the nervous system. (Fig. 2 b).

The mouth opening of the mature larva (Fig. 3 of *Aphidius ribis* Hal.) lies as far above the most anterior point of the head as the salivary gland orifice is below. The narrow œsophagus runs back to the middle of the third segment where it suddenly enlarges into the vast stomach, which almost fills the body cavity as far as the eleventh segment. The lining of the œsophagus is composed of a thin inner membrane and a single layer of large gland cells, surrounded by a layer of sustentative tissue. Outside of the whole, muscle fibres are visible. (Fig. 8 c). The proclinate gland cells are parallelograms in section, becoming irregular near the thicker portion where the œsophagus abruptly opens into the stomach. There is no definite proventriculus as Seurat ('99) suggests in his figure, but some of the cells at the juncture of the œsophagus and stomach project into the pouch and suggest a peritrophogen. However, no peritrophic membrane has been observed. The wall of the stomach has one or more layers of gland cells separated from the cavity by a thin membrane. These cells are rectangular, more or less rounded on the inner edge, which is the longer side of the cells situated in the forward part of the stomach, and the shorter side of those in the posterior portion. (Figs. 8, a and b).

Although the intestine is closely applied to the wall of the stomach, there is no open connection between them. The ileum and rectum are distinct. The latter has a thick outer membrane of sustentative tissue, resembling that of the œsophagus. It is filled with glandular cells provided with long

stems. A single cell starts at the membrane and extends till it almost meets those coming from the opposite wall. Each cell has a prominent nucleus in its stem and a granular secretion in its globular part. (Fig. 8 d). Such fully developed gland cells are remarkable in a non-functioning part of the alimentary tract, for there is no open connection between the stomach and intestine nor between the Malpighian tubules and intestine. This is contrary to the findings of Seurat ('99) who figures the tubules as opening into the intestine.

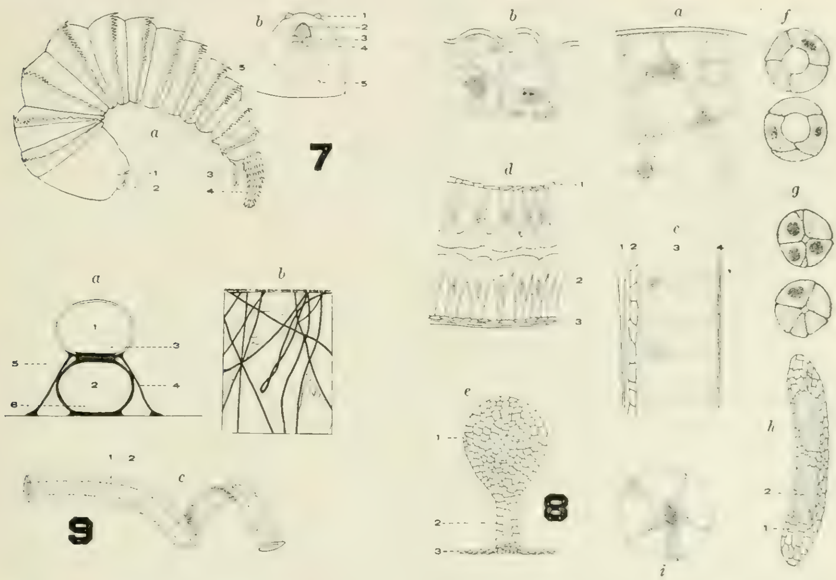


Fig. 7. *Ephedrus incompletus* Prov. *a*, First stage larva; 1, Mandible; 2, Antenna; 3, Appendage; 4, Tail; 5, Fringe of hairs. *b*, Ventral view of the head of the first stage larva. 1, Antenna; 2, Mouth opening; 3, Mandible; 4, Labium; 5, Papilla.

Fig. 8. *Aphidius phorodontis* Ash. *a*, Longitudinal section of the gland cells of the stomach near the center; *b*, The same, near the posterior extremity; *c*, Longitudinal section of the left half of the œsophagus (arrow indicates the direction of the food passage); 1, Muscle fiber; 2, Sustentative tissue; 3, Gland cells; 4, Inner wall. *d*, Longitudinal section of the closed intestine near the center; 1, Sustentative tissue; 2, Gland cells; 3, Muscle fiber. *e*, Longitudinal section of a single gonad; 1, Gonad proper; 2, Duct; 3, Ventral wall of the twelfth segment. *f*, Cross sections of the silk gland. *g*, Cross sections of the Malpighian tubule. *h*, Cross section of a paired ganglion; 1, Outer layer; 2, Inner layer. *i*, Adipose cell.

Fig. 9. *Praon simulans* Prov. *a*, Diagrammatic cross section of a cocoon; 1, Empty body of the aphid; 2, Cocoon proper; 3, Filled in slit through the ventral part of the aphid's abdomen; 4, Outer wall; 5, Inner wall; 6, Points of attachment to the substratum. *b*, Surface view of a portion of the outer wall. *c*, Silk; 1, Inner core; 2, Outer covering.

From the region where the stomach is applied to the intestine, the two Malpighian tubules arise and extend forward on each side to the fifth or sixth segment, where they end in an upward curve. In cross-section they are composed of three to six cells, surrounding a very small lumen, and have large nuclei. (Fig. 8 g).

NERVOUS SYSTEM.

In the second stage larva (*Aphidius phorodontis*, Fig. 2 a) the very conspicuous ventral nervous system consists of twelve ganglia and is so wide that it occupies one-third of the body cavity between the head and the anal segment. This proportion remains about the same till the fourth stage is reached, (Fig. 2 b), when the nervous tissue is reduced to about one-fourth of the contents of the body; and in the fifth stage it forms only a small part, (Fig. 3). In the fourth stage, the last ganglion (thirteenth) is larger and longer than the more central ganglia.

The nervous system of the mature larva (Fig. 3) was especially observed in *Aphidius ribis* Hal. The large supraœsophageal ganglion, located dorsally in the second segment, is about four times as large as each of the four following ganglia—the subœsophageal, situated in the second segment at the crotch of the two joining silk glands, and the three thoracic ganglia. The remaining eight ganglia, completing the series of thirteen, are of the same size, except the last, which is again larger and situated in the twelfth segment between the two gonads. The ganglia are all thick and lie close together. The commissures are also thickened, causing the ventral nerve chain to appear of almost the same width throughout. It is, of course, not circular in cross-section (see Fig. 8, h), but each ganglion is composed of two closely applied lateral halves which together form a sausage-shaped mass.

The gonads are two in number, bulb-like in shape, with a common duct (Fig. 8, e). Each is a solid mass of cells. The duct is partly hollow, but not yet open. (Opens on seg. 12. See description of Fig. 8, e.)

Lateral to the supraœsophageal ganglion is a large imaginal disc, that of the antenna, and lateral to this, but extending forward into the first segment, is the disc of the compound eye. The large disc of the mesothoracic wing and the smaller one of the metathoracic wing are centrally situated on each side of the

third and fourth segments. The three pairs of leg discs, lie ventrally in segments two, three and four, and the two pairs of discs representing the genitalic appendages in segments thirteen and fourteen. Just before pupation, these discs already exhibit the parts of the adult organs, so that, for example, the segments of the antenna are clearly visible.

No heart nor tracheal system has been observed in the larvæ.

SILK GLANDS.

The silk glands first become clearly visible in the fourth stage, as a slightly wavy, single tube in the dorsal region on each side of the stomach. Anteriorly these enter a common duct of smaller diameter in the region of the suture between the first two segments. (Fig. 2 b). In this stage, they are much narrower than the Malpighian tubules which originate at the juncture of the stomach and intestine and extend forward, parallel to the ventral line of the stomach, ending in the fourth segment.

In the adult larva the large, sinuous glands are the most conspicuous organs in specimens stained with borax carmine. (Fig. 3). They are composed of a single layer of cells, usually four in cross section, with prominent nuclei. The diameter of the lumen is almost as great as the thickness of the secretory epithelium. (Fig. 8 f). The two glands lead to a short duct in the head, close to the orifice. Posteriorly they terminate in an incomplete coil in the eleventh and twelfth segments.

LOCOMOTION OF THE LARVÆ.

The first stage larva is very active. I have examined carefully the youngest larva of *A. phorodontis*, which can move either backward or forward. To advance, the head is retracted and the tail drawn back dorsally. Then the head is suddenly shot forward, the tail elongates and gives a push downward. When the animal moves backward, the tail is not raised dorsally, but is pushed out in a line with the body. It is then drawn in with a hook-like movement, while the head is simultaneously retracted. The natural curve of the body causes the animal to move always in a circle. Yet, this is the only type of movement necessary for an animal enclosed in a rounded cavity like that of the aphid's body.

Pemberton and Willard ('18 b) say of *Diachasma tryoni:* "The first instar moves about by contorting the body, and its movements are aided by gripping fresh tissues coming into contact with the mandibles coincident with the body movements." It is possible that these Aphidiinæ may use their mandibles in such a way, but I have never observed them in the act.

In its later stages the larva is more or less torpid, moving slowly with worm-like waves of muscle contraction along the successive segments.

POSITION OF THE PARASITE IN THE BODY OF THE HOST.

In the majority of cases, the young larvæ (Stages I to III) are found in the posterior half of the abdomen. In twelve perfect specimens of *A. phorodontis*, nine were in the normal position. In one of the three abnormal cases the parasite was in the anterior part of the abdomen; in the second, in the middle; and in the third the larva was too large for the size of the host and occupied most of the abdominal cavity.

The later stages, IV and V, are curved so that the head and tail usually meet. If they are slightly straightened, the head is nearer the anterior extremity of the host. This position is very constant, as I have found only a single exception. The parasite is always confined to the abdomen.

FORMATION OF THE PUPAL ENVELOPE.

When the contents of the host's body has been exhausted, the gorged larva fills the cavity almost to the bursting point and then proceeds to cut an opening, along the midventral line of the abdomen. This slit soon becomes so widely spread by the strain on the delicate cuticle of the host that a broad oval opening is formed.* It must be a considerable strain on the fat and tightly housed insect to accomplish the movements necessary, but when once the hole is made, it starts diligently to work. First the edges of the now oval slit are attached to the substratum. Next the bottom is filled in, and the whole cavity is lined with strands of silk. Muesebeck ('18) observed that the Braconid, *Apanteles lacteicolor*, looped

* Webster ('08) considers that the parasite stretches out the aphid by certain movements which I am sure are only those made by the larva in spinning the cocoon after the slit has been cut.

the thread, but in this case, it is put on rather irregularly, sometimes with two or three superimposed so that the thread appears to be compounded.

The silken thread itself is very fine and tenuous, more oval than round in cross-section, brownish white and slightly opaque. It is composed of an inner core, with an outer covering. (Fig. 9 c). Branching of the thread sometimes occurs, but this is an exception rather than the rule.

Matheson ('07), in speaking of the silk glands of *Apanteles glomeratus* L., says that the anterior portion serves as a reservoir and the posterior as a secretory organ. The secretion is enveloped in a different material, "a peripheral layer of silk oxydized in the reservoir." The inner core and outer covering of this Aphidiine silk suggests the silk he describes, but as mentioned before, the parts of the silk glands are undifferentiated, as the same type of cells extend throughout the entire length of the organs.

If turned upside down while attaching the aphid, the larva will worm itself entirely out of its covering in its endeavor to reach some foundation. If the shell of the aphid is thus lost, the larva spins a cocoon, but I have never been able to bring one in this predicament to maturity. If the larva comes partly out and finds the substratum, it drags the aphid husk after it, just as a snail draws its shell, and soon sticks it down.

Praon similans Prov., after cutting the slit, leaves the aphid's body entirely, but uses it as a sort of roof. The now rounded slit is covered over, while tent-like walls of a light layer of silk, separated by a thin membrane (Fig. 9 b) serve to hold the aphid body over the larva, while it spins its cocoon underneath. (Fig. 9 a). This central capsule is made of the same silk as the outer walls, but is packed tightly and thickly together without any intervening membrane. How this membrane is formed I have been unable to determine; perhaps the silk strands are made more fluid by exuded juices from the mouth. One could hardly attribute to such simple glands the power of secreting thread and a membrane, probably fluid, at the same time.

The oval cut is entirely filled in and serves as the top of the main cocoon, which is of a rounded, oval shape and of about the same size as the dead aphid's body, exclusive of the appendages.

REARING THE PARASITES.

Three experiments in rearing *Aphidius phorodontis* under control were carried on in May and June with these results.

In the first experiment, four females parasitized, in four days, twenty-one aphids out of seventy six. The offspring took an average of twenty-three days until maturity.

In the second, three females parasitized, in four days, thirty-six aphids out of seventy, and the adults emerged in twenty days.

In the third, four females parasitized, in six days, twenty-eight out of twenty-nine aphids. The developmental period was approximately twenty days.

The hosts in the last experiment, as would be expected, were very heavily parasitized. Also, seventeen more aphids were present ultimately than at the start. The same is true in the first where six more were present. This increase is natural, as the viviparous female aphids are constantly laying their young.

In the three series of rearings, there were eleven cases out of the fifty-nine parasitized specimens where more than one larva was present in a single host; six cases with two, four cases with three, one with seven, and one with eight. In only two instances where two or three were present, were the parasites of the same age and these larvæ were in the first instar. In the others, one larva was much older, and the young ones were usually dead. In the case of the seven larvæ, all were in the first instar; but in that of the eight, three second stage larvæ and one first stage individual were alive, although the remainder were dead.

Since never more than one larva reaches maturity, a problem presents itself, concerning the reason for the disappearance of the supernumerary larvæ. Though usually dead in the presence of a later stage, they are not necessarily devoured when they die, nor are they killed; but they must be devoured sooner or later, since no vestige of them remains at the time of pupation. There are four possibilities for their death:

First, by starvation; but this can hardly occur, since the host always contains plenty of food material after the death of the larvæ. Starvation would be likely only if they were capable of digesting but one kind of food tissue, which might have already been consumed by the older larva.

A second possibility is through the action of some poisonous principle. Timberlake ('10) suggests that "the more advanced and stronger larvæ secrete or excrete some fluid or material into the body of the host, which eventually destroys their younger or weaker brothers and sisters."

Third, through deliberate injury by the older inhabitant. Pemberton ('18 a) pictures a larva *D. tryoni* with its mandibles buried in the body of an *Opius humilis* larva and observes that they feed on the extra parasites. In only one case did I find an old larvæ feeding on the half empty husk of a smaller one, but I was unable to determine if they were both the same species.

Fourth, by accidental injury. A slight mechanical injury, unobservable because of their minute size, might cause death, and afterwards, whether dead or alive, the animal would be devoured because it had the misfortune to be in the path of the sweeping mandibles of the dominant parasite. When the larvæ are all of the same size and strength, the idea of starvation or poisoning seems impossible. Therefore the survivor must be the one to escape injury. Yet I have never noticed an instance where all larvæ of the same stage were dead.

LENGTH OF LIFE.

Withington ('08) found a species of *Lysiphlebus* (= *Ephedrus*) on *Aphis maidis* which required thirteen to twenty-three days for development from egg to adult under a daily mean temperature of 62.6° F.

Hunter ('09) observed that 17.66 days was the average developmental period of *Lysiphlebus tritici* during the whole year.

During April and May, *Aphidius phorodontis* required approximately nineteen to twenty-three days. Some meager data, obtained during May and June, indicated from thirteen to eighteen days. The acceleration at this time is probably due to higher temperature.

The larval stages last about ten days and the pupal condition, four or five days.

Without food, the life of the adult varies from two to seven days, four days being the mean; with food, life is prolonged to eight days and longer, but the limit has not been determined.

SUMMARY.

1. Various larval types of parasitic Hymenoptera are defined.

2. Previous papers on the larval stages of the Chalcidoidea, Proctotrypoidea, and Ichneumonoidea are reviewed.

3. The life-histories of Aphidiinæ (Braconidæ) are discussed with special reference to the larval stages of *Aphidius ribis* Hal., *Aphidius phorodontis* Ash., *Lysiphlebus testaceipes* Cress., *Praon simulans* Prov., *Ephedrus incompletus* Prov., and *Diæretus rapæ* Curtis.

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THE PELASTONEURUS OF NORTH AMERICA

(Dolichopodidae, Diptera.)

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In the following pages I have described eleven new forms of *Pelastoneurus*, several of which have remarkable distinguishing characters. The accompanying plate gives drawings of wings or wing tips where it seemed that they would be a help in determining specimens.

Dr. J. M. Aldrich has greatly assisted me in the preparation of this paper by sending me specimens of several of the species described by him, thus enabling me to more fully differentiate these species and make out the new tables of species. He also sent me his undetermined material, among which were several interesting forms new to me.

The drawings were made by Mr. William Wild, of East Aurora, N. Y.

Pelastoneurus dissimilipes and **cyaneus** Wheeler.

These two forms, although very much alike in color and in the form of the hypopygium and its lamellæ are easily separated by the bend in the last section of the fourth vein. In *cyaneus* (Fig. 10) it is further from the cross-vein and much more abrupt than in *dissimilipes* (which is about as in 21), in the former it is bent near its apical third, the upturned portion being only about half as long as the part from the cross-vein to the bend; in *dissimilipes* the bend is before the middle and so gradual as to make it difficult to say exactly where it starts. The hind tibiæ are black in *dissimilipes*, but yellow in *cyaneus*. The fore femora are largely black in *dissimilipes* in all the specimens I have seen, they are usually wholly yellow in *cyaneus*, but sometimes a little blackened; the antennæ in this species is usually considerably yellow, still it may be almost black, but in all my specimens of *dissimilipes* it is nearly all black.

I have compared 23 specimens of *dissimilipes* with 43 of *cyaneus* and there does not seem to be any grading except a little in color.

In Dr. Wheeler's large paper on Dolichopodidæ in the Proc. of the Calif. Acad. of Sci., 3d Series, Vol. II, pl. 1, Fig. 21, he gives the drawing of a wing marked in "the explanation of Plate I, as *Pelastoneurus nigrescens*, female, wing," as no species of that name is mentioned by him and as the drawing is a good figure of the wing of *P. dissimilipes*, I think it was no doubt drawn from that species.

Pelastoneurus heteroneurus Macquart.

Female: Length, 4.5 mm. Face very wide and long, covered with brownish gray pollen, which is a little more yellowish below and is thin on upper part so that the metallic green ground color shows through; it is concave on upper portion and convex below; this lower part is longer than the upper, the dividing suture is not conspicuous but distinct, the pollen on the sides of the lower half of the lower portion is whitish. Palpi black with the edges yellow, they are covered with white pollen so as to appear white unless viewed obliquely. Antennæ yellow, third joint very small and mostly blackish; arista black, feathered with long hairs. Front shorter than wide, violet with green reflections in the middle. Orbital cilia wholly black.

Dorsum of thorax greenish black with a narrow violet line on each side of the acrostichal bristles, on the posterior slope these lines are wider and more conspicuous; scutellum green with a median violet line; the dorsum of the thorax is dulled with brownish pollen, which gives it a spotted appearance; pleuræ more green with white pollen. Abdomen green with the last segment violet; it has abundant white pollen, which forms spots on the sides of the segments; the bristles on the hind margin of the last segment are strong.

Fore coxæ yellow, infuscated at base, on the anterior surface the infuscation extends about one-third their length, on the outer surface nearly three-fourths their length, but narrower apically; middle and hind coxæ black with yellow tips; the fore and middle pairs with numerous black hairs. Femora yellow; posterior pair narrowly but sharply blackened at tip except on lower surface. All tibiæ yellow. All tarsi brownish, still the first and second joints more or less yellowish. Calypters and halteres pale yellow, the former with black cilia.

Wings grayish, tinged with brownish in front; last section of fourth vein with its bend near its end and very abrupt, although broadly rounded, this upturned portion only a little more than one-third as long as the straight portion extending from the cross-vein to the bend (Fig. 23) and but little longer than the cross-vein, which is at right angles to it and about as long as the last section of the fifth vein.

Redescribed from one female sent me by C. W. Johnson and taken by him at St. Augustine, Fla., April 19, 1919. Type location, "North America."

This was described from a female by Macquart, in his Dipteres Exotique, Vol. II, Supp. IV, p. 128; and figured on Pl. XII, Fig. 10, as *Dolichopus heteroneurus*. I do not know as it has since been recognized, so I am redescribing it here, his description being rather meager. It is readily recognized by the great distance of the bend in the last section of the fourth vein from the cross-vein, the wholly black orbital cilia and the color of the legs and feet. The form and color of the face and front are also rather distinctive.

Pelastoneurus nigrifacies, sp. nov.

Male: Length, 4 mm.; of wing, 3 mm. Face wide, black, very shining, the suture below the middle; face concave above the suture, convex below; the lower portion has a narrow margin of white, almost silvery, pollen along the lower edge and on the sides, where it widens above at the suture. Palpi blackish with apical half yellowish red and with a few black hairs. Front shining violet on the sides, more black in the middle. Antennæ brown; lower edge of first joint and most of second reddish yellow; third joint rather pointed. Arista feathered with rather long hairs on apical third. Lower orbital cilia white.

Thorax dark green; dorsum dulled with brown pollen and with violet reflections; the ante-alar black spots nearly divided by the green of the dorsum, the white spot at the suture indistinct in described specimen; there is quite a distinct spot of whitish pollen in front of the scutellum; this pollen has a brownish cast when viewed in certain lights. Abdomen dark green with spots of white pollen on its sides. Hypopygium black; its lamellæ long, rounded at tip, fringed with black hairs (they are formed very much as in *vagans* Loew).

Fore coxæ brown, yellow at extreme base and at tip, their anterior surface with black hairs. Middle and hind coxæ black with yellow tips. Femora yellow, posterior pair black at tip, except on lower edge. Tibiæ yellow, anterior pair brownish above, middle ones narrowly black at tip and with three brown rings; posterior ones quite brownish, broadly black at tip and with three darker rings (they are probably sometimes yellow with three brown rings). Fore tarsi blackish from the tip of the first joint, fifth joint (Fig. 9) rather large, with the inner claw elongated and bent back along the lower edge of the joint, which has a small prominence. Middle tarsi black from the tip of the first joint, hind ones wholly black; second joint of hind tarsi only a little longer than the first. Calypters and halteres pale yellow, the former with black cilia.

Wings grayish, veins brown; first section of costa not enlarged; last section of fourth vein a little bent at about the length of the cross-vein from that vein and then gently arched, approaching third at tip (Fig. 8); last section of fifth vein about one and a fourth times as long as the cross-vein.

Described from one male taken at Amates, Gautemala, Jan. 18, 1905. Type in the author's collection.

There are three species with the inner claw of fore tarsi enlarged so as to form a grasping organ. Dr. Aldrich described two of these. *Hamatus* Ald. has the legs and feet almost wholly black, the antennæ are also black and the hypopyginal lamellæ short, in both the other forms the legs are yellow, the antennæ partly yellow, and the lamellæ large. *Nigrifacies*, new species, differs from *unguiculatus* Ald. chiefly in the form and color of the face, but the last section of the fourth vein is a little longer and more arched in *nigrifacies*. The face in *unguiculatus* is conspicuously divided by a longitudinal groove, so that there are two prominant convexites below, the depressed lower part extending up between them as a slender triangle, while in *nigrifacies* the upper part is decidedly concave and extends down as a point in the middle of the face onto the lower part, which is very short, the face not having a trace of a groove or depressed line in the center. The face in *unguiculatus* is opaque with pollen, while in this new species it is shining, polished black both above and below the suture, except that it is narrowly white pollinose along the lower orbits.

Pelastoneurus ramosus, sp. nov.

Male: Length, 3.75 mm.; of wing, 2.75 mm. Face wide, the suture below second third, the upper part with quite a distinct depressed median line, and with a shallow depression across its middle, the lower part but little convex; in the type the face is black with a little gray pollen along the sides and in the sutures (perhaps it has been rubbed). Front blue with yellowish brown pollen along the orbits and above the antennæ; palpi a little infuscated at base, their hairs mostly yellowish. First two antennal joints yellow; third mostly brown, about as long as wide, cut off rather abruptly at tip, so as to make them subquadrate. The orbital cilia appear to be wholly black.

Thorax bronze green, its posterior slope violet, dorsum with gray pollen along the front. Abdomen green. Hypopygium (Fig. 16) black, shining on upper part, it consists of two parts of nearly equal length, the basal part being a little more slender; its lamellæ black, large, wide at base, narrowing rather abruptly into a long curved point, which makes them somewhat sickle-shaped; they are fringed with yellow hairs, which are short on outer, longer on inner edge, especially towards the apex; inner appendages blackish, long, linear, elbowed, each with four yellow bristles which are branched like the limb of a tree.

Fore coxæ wholly yellow with a few small black hairs in the anterior surface; middle and hind coxæ black with yellow tips. Femora and

tibiæ yellow. Fore tarsi about as long as their tibiæ, yellow with the fifth joint black. Middle and hind tarsi infuscated from the tip of the first joint, the latter with the first joint about two-thirds as long as second. Calypters yellow, their cilia yellowish. Halteres yellow, the knob of one black at tip, the other wholly yellow.

Wings uniformly tinged with blackish; first section of costa not thickened; last section of fourth vein rather evenly curved from the cross-vein to its tip; it is furthest from third vein near the middle of its length and approaches third to the tip; last section of fifth vein about as long as the cross-vein, (Fig. 17).

Described from one male taken at Petersburg, Chesterfield Co., Va., June 1, and one male taken at Lafayette, Ind., July 12, 1918, by Dr. J. M. Aldrich.

Holotype in the author's collection.

Pelastoneurus arboreus sp. nov.

Male: Length, 3 mm.; of wing the same. Face wide, upper half gently concave with a depressed median line, and with thin yellowish pollen which does not conceal the ground color; lower half rather flat, with thick yellow pollen; across the middle of the face the pollen is more brown. Palpi covered with thick yellow pollen and with a few black hairs. Front shining violet with a yellowish central space. Orbital cilia wholly black.

Thorax green with violet reflections on the posterior half of the dorsum and dulled with brown pollen; the velvety black line above the root of the wing broad, reaching the suture, where there is a rather large white spot below it; there is another black spot on each side just before the scutellum, which is bronze-green. Abdomen bronze green with white pollen on the sides of the segments, sixth segment covered with thin gray pollen. Hypopygium (Fig. 14) greenish black, pedunculate, not very large, its lamellæ large black, slightly reddish at base, where there are minute yellow hairs below; they are nearly as long as the main portion of the hypopygium, but not quite as wide, somewhat oval in outline, half as broad as long, fringed with long black hairs, which appear pale in certain lights; a pair of long slender appendages above are not quite as long as the lamellæ and have several pale, branched bristles on their lower surface.

Fore coxæ and all femora and tibiæ yellow; middle and hind coxæ blackened on outer surface. Fore tarsi yellow with last joint blackened. Middle and hind tarsi infuscated from the tip of the first joint. Calypters and halteres yellow, the former with black cilia.

Wings dark grayish; last section of fourth vein quite abruptly bent at its middle, ending close to the tip of third vein; last section of fifth vein but little longer than the cross-vein (Fig. 15); the hind margin of the wing slightly indented at tip of fifth vein.

Female: Face with a broad brown stripe, its sides and the palpi with grayish pollen; the lower half conspicuously convex. Fore and middle coxæ black almost to their tips. Thorax with some yellowish brown pollen on the dorsum.

Described from two males and two females. One male which I am making the holotype was taken at Lafayette, Ind., May 25, 1916, by Dr. J. M. Aldrich; the other specimens were taken at Slidell, La., July 2–6, 1905, by J. S. Hine.

Holotype in the collection of J. M. Aldrich.

This is the third species to be described from North America having the inner appendages of the hypopygium long and slender with their bristles branched like the limb of a tree. Dr. Loew described the first form; it was from Texas; this is *furcatus* and has the hypopyginal lamellæ forked and fringed with black hairs. In the other two forms which are described above, the lamellæ are entire, not forked; in *ramosus* the lamellæ are somewhat sickle-shaped and acutely pointed (Fig. 16) and fringed with yellow hairs; in *arboreus* they are oval and scarcely a little pointed at tip, which is somewhat rounded (Fig. 14), and although their hairs appear black in certain lights, still in others they are decidedly yellow.

Pelastoneurus aurifacies, sp. nov.

Male: Length, 2.75 mm.; of wing, 2.5 mm. Face moderately wide, not wider below, its suture nearly at the middle of its length; lower portion rather flat, with a slightly depressed median line and another shorter depressed line on each side in front; upper portion almost golden yellow, the lower part a paler yellow, still somewhat golden. Palpi rather small, covered with white pollen and a few black hairs. Front opaque with brown pollen on lower half, above with a shining blue spot on each side of the ocellar tubercle. Orbital cilia wholly black. First two joints of the antennæ yellow, third mostly brown, yellow only at base. (Arista broken off in type).

Thorax and scutellum shining blue-green, when viewed obliquely the dorsum appears more opaque with yellowish brown pollen; when seen from in front this pollen leaves two shining lines on the dorsum; pleuræ with whitish pollen; the ante-alar black spot and the usual white spot on the suture can scarcely be seen. Abdomen bronze or coppery, rather dull, with spots of white pollen on the sides, last segment wholly covered with whitish pollen. Hypopygium rather short, black, dulled with whitish pollen; its lamellæ blackish, more yellow at base, small, rounded, fringed with a few conspicuous black hairs.

Fore coxæ yellow with black hairs on their anterior surface; middle and hind coxæ black with yellow tips. Femora and tibiæ yellow.

Fore tarsi equal to their tibiæ in length, first three joints yellow, last two black; middle and hind tarsi black from the tip of the first joint, the latter with the first joint about two-thirds as long as the second. Calypters yellow with black cilia. Halteres yellow with the knobs a little brownish.

Wings tinged with brown, the hind margin more grayish; first section of costa not thickened; last section of fourth vein quite abruptly bent, (Fig. 12), the bend being very near its middle tip, close to the tip of third vein; last section of fifth vein not longer than the cross-vein.

Described from one male which I took at Bradentown, Fla., in March. Type in the author's collection.

Pelastoneurus aldrichi sp. nov.

Male: Length, 4–4.5 mm.; of wing, 3.5–3.7 mm. Face wide, covered with white pollen, which is thin on the upper concave portion, where the metallic ground color shows through more or less; the convex lower part is not as long as the upper portion. Palpi blackish, with yellow margin and black hairs, so thickly covered with white pollen as to appear white when viewed in an oblique direction. Front violet, which color extends onto the upper part of the occuput. Antennæ yellow; third joint about as long as wide, rounded at tip, its apical half brown; arista feathered with rather long hairs. Orbital cilia wholly black.

Thorax violet, more green on the anterior slope and median line; pleuræ black with white pollen; the black line above the root of the wing and the white sutural spot distinct. Abdomen deep violet with the sides below green; sometimes the green is confined to the sides of the first segment; the usual spots of white pollen seem to be confined to the sides of the second, third and fourth segments; most of the small sixth segment covered with white pollen. Hypopygium and its appendages black; its lamellæ rather small, fringed with long black hairs and with a few minute pale ones at their root, there are very small testaceous appendages at their base; inner appendages stout, horn-like, curved and acutely pointed, longer than the lamellæ; at the upper edge of the tip of the hypopygium is a small appendage protruding a little and bearing a brush of short black hairs.

Coxæ and femora black, trochanters, narrow tips of coxæ and base and tip of femora yellow; fore coxæ covered with white pollen and coarse black hairs on anterior surface. Tibiæ yellow, sometimes the posterior pair quite brown, at least at base, the middle ones may also be a little brownish at base; bristles of middle and hind tibiæ usually inserted in brownish spots; apical half of fore tibiæ on anterior surface with a glabrous streak; middle and hind tibiæ almost glabrous above, posterior ones with the upper row of hairs on inner edge distinctly longer than those on outer surface, especially near the tip. Fore tarsi a little longer than their tibiæ, yellow, the upper surface of the three last joints infuscated, their lower surface nearly glabrous and covered

with white pollen; the lower row of hairs on the anterior edge black, close, stiff and rather long. Middle and hind tarsi brown, darker apically, the posterior ones with the second joint considerably longer than the first. Calypters and halteres yellow, the former with black cilia, still it appears quite yellow in certain lights.

Wings grayish (Fig. 3); last section of fourth vein quite abruptly bent near its third fifth; the cross-vein a little more than its length from the wing margin, measured on fifth vein.

Female: Face formed as in the male, with a broad bronze brown stripe in the middle, leaving only a narrow edge of white pollen next the eyes, which is wider below; palpi and antennæ colored as in the male; thorax green with its posterior slope and the scutellum violet; abdomen green, with large spots of white pollen on its sides; coxæ as in the male; femora more or less black, sometimes the posterior pair almost yellow; tibiæ as in the male; fore tarsi colored as in the male, about as long as their tibiæ; middle and hind tarsi black from the tip of the first joint, second joint of the latter but little longer than the first; cilia of the calypters and the wings as in the male.

Described from sixteen males and eleven females taken by by Dr. J. M. Aldrich in Utah; nineteen were taken at Brigham, July 4, 1911, and seven at Salt Lake City, July 18–20, 1917.

Holotype and Allotype in the collection of J. M. Aldrich.

I am pleased to dedicate this interesting and distinct species to Dr. Aldrich, who took the type specimens and who has described so many of our species in this genus.

Pelastoneurus caeruleus sp. nov.

Male: Length, 4 mm.; of wing, the same. Face wide, with the suture not quite half way down, making the concave upper portion scarcely as long as the convex lower part; above it is bright metallic green, the lower part thickly covered with white pollen. Palpi blackish with yellow apical margin, its hairs black. Front violet with the edges narrowly green. Antennæ yellow; third joint short, rounded and blackened at tip; arista feathered with long hairs. Lateral and inferior orbital cilia whitish, about eight of the upper cilia on each side black.

Dorsum of thorax dark violet, with green reflections and a median steel-blue vitta, its anterior slope more bronze; pleuræ blackish with white pollen, dorsum with thin brownish pollen, which is more conspicuous on the posterior slope; the black spot above the root of the wing narrow, but reaching the suture, where there is a conspicuous white spot below it. Abdomen green with spots of white pollen on its sides, sixth segment almost wholly white pollinose. Hypopygium green, rather thick and large; its lamellæ slender, black, extending upwards and outward, they are a little yellow at base where they have small, yellow-haired, yellow, lamellæ-like appendages, extending beyond these are two thick yellow inner appendages which have a slender black bristle below near the middle of their lower edge.

Fore coxæ yellow, a little blackened at extreme base and with black hairs on their anterior surface; middle and hind coxæ black with yellow tips. Femora and tibiæ yellow; middle tibiæ with a pair of bristles below near their middle. Fore tarsi about one and a third times as long as their tibiæ, almost wholly yellow. Middle and hind tarsi mostly brownish.

Wings dark grayish; last section of fourth vein bent at its middle; last section of fifth vein about as long as the cross-vein; anal angle rounded, not very prominent.

Female: Almost like the male, except that the fore tarsi are but little longer than their tibiæ.

Described from three males and two females taken at Santa Lucia, Gautemala, February 2. I received these specimens from Prof. James Hine.

Holotype and Allotype in the author's collection.

This is very much like *argantifer* Ald., agreeing in the form and color of the face and hypopyginal lamellæ and in the venation of the wings; but differ in having the inner hypopyginal appendages yellow with a black bristle below; in *argantifer* these appendages are black and have no bristle below, but have a long, curved, black bristle at base which is not found in this species. This form also has one black bristle at the lower end of the orbital cilia, while *argentifer* has no black bristle on the lower part of the head.

Pelastoneurus costalis sp. nov.

Female: Length, 4 mm.; of wing the same. Face wide, covered with grayish white pollen, which is a little brownish in the center, the green ground color shows through a little on the concave upper portion, which is decidedly shorter than the convex lower part. Antennæ yellow, the upper edge of the first joint and most of the third joint black; arista feathered with long hairs. Front shining, almost black, still with slight blue reflections; orbital cilia white with about ten of the upper ones on each side black.

Thorax very dark green, dorsum dulled with brown pollen; the usual black spot above the root of the wing rather narrow, but reaching the suture; the white spot at the suture large, reaching the humeri; pleuræ with white pollen. Abdomen green, the hind margins of the segments black; the spots of white pollen on the sides of the segments large.

All the coxæ black, a little yellow at tip. Femora and tibiæ yellow, tips of hind femora above and tips of all tibiæ black. Fore tarsi blackened almost to their base; middle and hind tarsi black from the tip of the first joint. Calypters and halteres yellow, the former with black cilia.

Wings (Fig. 22) dark grayish; costa much enlarged before the tip of the first vein, especially when viewed from the front of the wing; last section of fourth vein gently arched from the cross-vein to its tip, which is close to the tip of third vein.

Described from one female which was taken at Atoyac, Vera Cruz, May. Type in the collection of J. M. Aldrich.

An interesting form, it being the only species in the genus known to me with enlargement of the costa. It is the third species we have with black fore coxæ where the lower orbital cilia is pale, the others being *vagans* Loew; and *occidentalis* Wheeler.

Pelastoneurus insulanus sp. nov.

Male: Length, 3 mm.; of wing, 2.5 mm. Face rather wide, covered with white pollen, upper half slightly concave with a depressed median line, lower half a little convex. Palpi black with black hairs. Front violet. Occiput green. Antennæ reddish yellow, rather large; third joint a little longer than wide; arista feathered with rather long hairs. Orbital cilia whitish.

Dorsum of thorax brown, a little shining, the black spot above the root of the wing narrow but distinct, the silvery white spot at the suture conspicuous; scutellum bronze-green, its center deep black; pleuræ greenish. Abdomen blackish with large spots of white pollen on the sides of the segments. Hypopygium and its lamellæ black; lamellæ elongate, ribbon-like, fringed with long black hairs, their base yellow, oval and fringed with yellow hairs; inner appendages blackish, small, lamellæ-like.

Fore coxæ yellow, a little infuscated at base on outer side; middle and hind coxæ black with yellow tips. Femora and tibiæ yellow; hind femora black at tip on upper edge. Fore and middle tarsi a little longer than their tibiæ, yellowish brown, darker at tip. Calypters and halteres yellow, the former with black cilia.

Wings tinged with brownish; last section of fourth vein bent at its middle, so as to approach third at tip (Fig. 20); cross-vein one and a fourth times its length from the wing margin, measured on fifth vein.

Described from one male taken by Baker at Havana, Cuba. Type in the collection of Dr. J. M. Aldrich.

Pelastoneurus nigricornis sp. nov.

Male: Length, 4 mm.; of wing the same. Face wide, covered with silvery gray pollen, the upper portion above the suture shorter than the lower part. Palpi black with yellow edges and whitish pollen. Front green, more blue near the orbits. Antennæ wholly black; third joint about as long as wide, rounded at tip; arista feathered with long hairs. Orbital cilia wholly black.

Thorax green, with violet reflections on the posterior half of the dorsum; the black spot reaching from the root of the wing to the humeri is narrow and not conspicuous, there is a spot of whitish pollen above the root of the wing and a large one below at the suture, but these spots are not glistening white as in some species; scutellum green, more blue on the median line and on the margin. Abdomen green with large spots of white pollen on the sides of the segments; sixth segment wholly white pollinose. Hypopygium black; its lamellæ oval, testaceous, not large, fringed with rather long, black hairs on their edges, which are blackish, their sides nearly bare. The inner appendages are somewhat thickened and nearly as large as the lamellæ; above these at upper apical corner of the hypopygium are small appendages with short hairs at tip.

Coxæ black, with narrow yellow tips, fore coxæ covered with snow white pollen and black hairs on their anterior surface. Fore femora blackened on basal half; middle ones blackened on upper and lower edges at base and hind ones at tip on upper edge; fore and middle tibiæ, fore tarsi and first joint of middle tarsi, except extreme tip, rather pale yellow, remainder of middle tarsi black. Fore tarsi nearly bare below where they have a little white pollen. Hind tibiæ and base of their tarsi brownish yellow. Middle tibiæ with two bristles below, one before the middle and one near apical third. Calypters and halteres yellow, the former with black cilia.

Wings (Fig. 1) about as in *P. dissimilipes* Wh. They are nearly hyaline; only a little grayish.

Described from one male, taken at Atherton, Mo., August 12, 1901.

Type in the collection of Dr. J. M. Aldrich.

This is almost like *dissimilipes* Wh. The venation, antennæ, face and general color are the same; the hypopyginal lamellæ are somewhat different, although at first sight they might be thought to be alike, they differ, however, in the lamellæ, being a little smaller and more oval, not at all triangular, and also in having their outer surface bare or nearly so; while in *dissimilipes* the outer surface is covered with long black hairs, as well as their edges; this form also has large inner appendages which are not found in *dissimilipes.* In the type specimen the small appendages at upper apical corner of the hypopygium has only short hairs at tip as far as I can see, but the similar appendages in *dissimilipes* have long hairs at tip. In this species the fore and middle tibiæ and fore tarsi are not at all infuscated in the single specimen before me, while in *dissimilipes* they are quite black in all my specimens. Both species differ from *cyaneus* Wh. in the venation of the wings, Fig. 10 being that of *cyaneus* and Fig. 1 is that of *nigricornis*, and also about as that of *dissimilipes.*

Pelastoneurus tibialis new species.

Male: Length, 4 mm. Face wide, silvery white, suture above the middle. Palpi blackish with silvery pollen and black hairs. Front bronze brown or blackish, rather dull. Antennæ black, first and second joints slightly yellowish at tip below; third joint scarcely as long as wide, rounded at tip; arista as long as the antenna, feathered with long hairs. Orbital cilia wholly black.

Thorax bronze brown with brown pollen, sometimes it has green or violet reflections or stripes on the dorsum; there are no black dots at the root of the bristles, at least none that are conspicuous; pleuræ black with a little silvery pollen. Scutellum bronze colored. Abdomen green with bronze reflections. Hypopygium black; lamellæ shining black, somewhat triangular, convex on outer surface, with black hairs on the edges and on the outside of apical half, inner appendages a little yellowish, not conspicuous; upper outer angles of the hypopygium with several bristles, but not prolonged.

Coxæ black with narrow yellow tips; anterior pair with silvery pollen and black hairs on the front surface. Fore femora black with apical third and extreme base yellow; middle ones mostly black on basal half; posterior pair yellow with the tip slightly brownish above. Fore tibiæ yellow, usually a little blackened at base above, middle tibiæ wholly black (in one specimen they are yellow with a black tip and base). Hind tibiæ yellow with the base and sometimes the tip black. Middle tibiæ with two bristles near the lower surface besides those on upper side. Fore tarsi yellow, as long as their tibiæ, first joint as long as the three following joints taken together, fourth joint the shortest. Middle and hind tarsi black from the tip of the first joint, the latter with the first and third joints of nearly equal length, second considerably longer. Calypters, their cilia and halteres yellow.

Wings grayish; venation about as in Figure 1, except that the last section of the fifth vein is less curved.

Female: Colored about as in the male, except the legs and face. Face brownish, with the sides quite widely whitish and the lower edge shading into grayish. Femora and tibiæ yellow. Tarsi about as in the male. Cilia of the calypters black with several of the upper hairs white.

Described from three males and one female taken by Mr. C. F. Adams, at Jemezsprings Mts., New Mexico, in June.

This is very near *dissimilipes* Wheeler. The male differs in the color of the tibiæ, and the hypopygium does not seem to have any appendages on the upper outer corners as in *dissimilipes*, but only a few bristle-like hairs. The female differs in having the first and second joints of the antennæ distinctly yellow below; the face is grayish, especially below, and the white pollen on the sides of the face is considerably wider.

Pelastoneurus dorsalis new species.

Male: Length, 4 mm. Face wide, covered with silvery white pollen, its suture above the middle; upper portion a little concave with a median, longitudinal, depressed line; lower part convex with the oral margin rounded. Palpi black, with yellow edge and black hairs. Front green with blue and bronze reflections. Antennæ black with first joint a little yellow below; third joint about as long as wide, rounded. Arista as long as the antenna, feathered with rather long hairs. Orbital cilia wholly black.

Thorax green, dorsum with purple reflections; the black stripe above the root of the wings is not conspicuous, the spot of white pollen at the suture large; humeri with a little white pollen; there are stripes of white pollen, which has a greenish shade in certain lights, along the lines of dorsocentral bristles, these lines are broken into spots by the black dots at the insertion of the bristles; on each side of the acrostichal bristles is a purplish brown line; scutellum green, with a depression on each side of the median line. Abdomen green with the incisures metallic brown, its hairs long and black; it is dulled with white pollen, which forms large spots on the sides of the segments; last segment wholly silvery pollinose; fifth segment with a row of long, black bristles on its hind margin. Hypopygium black, with a very short peduncle; it has a patch of black hairs on the left side at base; lamellæ rather large, shining black, still a little dulled with white pollen, fringed with rather long, slender, brown hairs.

Coxæ black with silvery white pollen; anterior pair with the extreme tips yellow, hairs on anterior surface and bristles at tip black. Fore femora black on basal half, yellow on apical half; middle ones yellow with their lower edge a little blackened and with a row of black hairs on their lower anterior edge, which are not very long. Hind femora wholly yellow, with a large preapical bristle above and stiff black hairs on lower outer edge, which are longer apically, the last ones bristle-like. All tibiæ yellow; middle pair with two rather small bristles on lower anterior edge; extreme tip of middle pair and extreme base and tip of hind ones a little blackened, the latter with the two rows of bristles above large and with a glabrous line between them; they have no bristle below. Fore tarsi about as long as their tibiæ, infuscated from the tip of the first joint, which is as long as the following three taken together; third and fifth of equal length, fourth slightly shorter. Middle tarsi longer than their tibiæ, black from the tip of the first joint and with the fourth and fifth joints of equal length. Hind tarsi longer than their tibiæ, yellowish at base, becoming black at tip; first and third joints of equal length, second longer. Calypters, their long delicate cilia and the halteres yellow.

Wings grayish; last section of fourth vein about as in *arboreus* (Fig. 15), but the last section of fifth vein is not so much bent; anal angle rounded.

Described from one male taken at San Evaristo, Lower California, June 10, 1921, by Edward P. Van Duzee.

Type in the collection of the California Academy of Sciences.

Pelastoneurus barbicauda new species.

Male: Length, 3.2 mm.; of wing, 2.7 mm. Face rather wide, silvery white, its suture near the middle, upper portion with a depressed median line, lower part convex, its lower edge nearly straight, but little rounded. Palpi black with yellow edges, black hair and white pollen. Antennæ yellow; third joint largely brown, rounded; arista feathered with long hairs. Front blue with the upper edge violet, lower half covered with brown pollen. Orbital cilia wholly black.

Dorsum of thorax metallic brown, dulled with brown pollen; posterior slope violet, but with a green space in the middle before the scutellum; the velvety black stripe above the root of the wing distinct and quite wide; there is a round spot of silvery white pollen at the suture and another smaller one above the root of the wing; pleuræ green with white pollen; scutellum coppery. Abdomen green with black hairs and thin white pollen, which forms rather small spots on the sides of the segments; fifth segment with a row of long black bristles on its posterior margin. Hypopygium greenish with the usual patch of black hairs on the left side at base; lamellæ rather large, shining black with the stem a little yellowish at root, where there are short yellow hairs, outer part rounded and covered with long, stiff, black hairs on both edge and disk.

Coxæ black with yellow tips, silvery white pollen and black hair and bristles. All femora yellow, without longer hair below; middle pair with one preapical bristle, posterior ones with two preapical bristles, one above and one below on outer surface, and are black above at extreme tip. All tibiæ yellow; posterior pair slightly infuscated at extreme tip and on upper edge of extreme base. Middle and hind tibiæ with one large bristle on lower anterior surface. Fore and middle tarsi about as long as their tibiæ, with their first joint a little longer than the two following taken together; anterior pair mostly yellowish, stout and rather hairy, third and fifth joints of equal length, fourth slightly shorter; middle tarsi black from the tip of the first joint, with fourth and fifth joints of equal length. Hind tarsi wholly black, still the first joint is slightly yellowish at base, first joint slightly shorter and the second longer than third. Calypters and halteres yellow, the former with long black cilia.

Wings grayish (Fig. 18); last section of fourth vein bent beyond its middle. Anal angle of wing rounded.

Female: Color and tarsi as in the male, except that the face is brown with its edges narrowly silvery white. The fore coxæ are largely yellow on inner and anterior surfaces; the wings are more tinged with brown than in the male.

Described from two males and three females; two pair were taken at San Evaristo, Lower California, June 10, 1921, and one female taken at Loreto, Lower California, May 19, 1921, by Edward P. Van Duzee.

Type in the California Academy of Sciences.

TABLE OF SPECIES

Found in America North of Central America, and from the West Indies.

MALES.

1. Femora black, at least one pair largely black..............................2
   Femora yellow, the tip of the hind pair or the upper edge may be black....8
2. Half, or more than half, of the fore femora black; middle ones black at base; hind ones yellow with or without a black tip; wings about as in figure 1..............................3
   All femora and tibiæ almost wholly black..............................7
3. All tibiæ black or considerably infuscated, hind ones always black, (Calif.)..............................*dissimilipes* Wheeler.
   Anterior and posterior tibiæ largely yellow..............................4
4. Hind femora wholly yellow..............................5
   Tip of hind femora black..............................6
5. Middle tibiæ wholly yellow; thorax green with purple reflections and conspicuous black spots at base of dorso-central bristles, (Lower California)..............................*dorsalis*, new species.
   Middle tibiæ wholly black or spotted with black; thorax bronze brown with green reflections, without noticeable spots at base of bristles, (New Mexico)..............................*tibialis*, new species.
6. Cilia of the calypters black, (Missouri)..............*nigricornis*, new species.
   Cilia of the calypters whitish, (New Mexico)..........*tibialis*, new species.
7. Antennæ almost wholly black; inner claw of fore tarsi much enlarged, wing as in figure 2, (Mexico)..........................*hamatus* Aldrich.
   Antennæ reddish yellow with the third joint black; claws of fore tarsi normal, wing as in figure 3, (Utah)................*aldrichi*, new species.
8. Wings with one or more brown spots or clouds, other than those that may be on the veins..............................9
   Wings without spots, except sometimes on the cross-vein and on the middle of last section of fourth vein..............................11
9. Wings with a rounded, but not very sharply defined, apical spot, as in figure 4, (Mexico)..............................*bigeminatus*, Aldrich.
   Wings with numerous spots in the cells..............................10
10. Last section of fourth vein uniformly approaching third towards its tip, figure 5, (Mexico)..............................*punctipennis*, Say.
    Last section of fourth vein abruptly bent towards third at a point beyond its middle, figure 6, (Florida)......................*pictipennis*, Wheeler.
11. Thorax with a more or less conspicuous spot of white pollen before the scutellum, which is best seen when viewed from behind. Hypopyginal lamellæ blackish..............................12
    Thorax without such a spot, or the pollen forming it more brown........15
12. Hypopyginal lamellæ rather small; last section of fourth vein abruptly bent at its middle; claws of fore tarsi normal..............................13
    Lamellæ rounded at tip, long; last section of fourth vein only slightly arcuated, approaching third from the cross-vein, about as in figure 8; inner claw of fore tarsi enlarged as in figure 9..............................14
13. Antennæ black with first joint narrowly yellow below, (N. Y., Fla., Calif.)..............................*longicauda*, Loew.
    Antennæ yellow with apical half of third joint blackened, (Lower California)..............................*barbicauda*, new species.
14. Face covered with white or brownish pollen, (W. I., Mex., C. R., Guatemala)..............................*unguiculatus*, Aldrich.
    Face black, very shining, with only a narrow border of white pollen on the lower portion of the orbits, (Guatemala)....*nigrifacies*, new species.
15. Orbital cilia wholly black..............................16
    Inferior orbital cilia pale..............................30
16. Fore coxæ black, more or less yellow at tip..............................17
    Fore coxæ yellow, sometimes a little blackened at base....................20

17. Abdomen dark green or bronze-green; coxæ almost wholly black......... 18
Abdomen deep violet...19
18. Outer hypopyginal lamellæ somewhat crescent-shaped, inner appendages with long, delicate, pale hairs; first and second antennal joints black above, (N. Y., Fla.).................................*abbreviatus*, Loew.
Outer lamellæ large, almost round with a short stem; inner appendages almost bare; first and second antennal joints wholly yellow, (Lower California)....................................*barbicauda*, new species.
19. Bend in last section of fourth vein near apical third, figure 10, (Calif., Mex., Nev., Ariz., S. D.)...........................*cyaneus*, Wheeler.
Bend in last section of fourth vein at its middle, figure 7, (Fla., N. Y., Calif.)..*longicauda*, Loew.
20. Hypopyginal lamellæ divided, forming four long filaments, (Kansas). *kansensis*, Aldrich.
Hypopyginal lamellæ of different structure, blackish......................21
21. Hypopyginal lamellæ small, rounded, or crescent-shaped..................22
Lamellæ large, somewhat pointed at tip....................................25
22. Face with a more or less distinct brown line or band; dorsum of thorax rather opaque, brown; wing as in figure 11, (N. Y., Ill., Fla., Mex.). *lugubris*, Loew.
Face of male without brown band or line; dorsum of thorax shining......23
23. Face thickly covered with yellow pollen, wings as in figure 12, (Florida). *aurifacies*, new species.
Face with white pollen, the bluish ground color sometimes showing through on upper portion...24
24. Hypopyginal lamellæ rounded, with short black hairs on the edge and minute yellowish ones on the surface, wing as in figure 13, (La., Fla., Ga.)...*parvus*, Loew.
Lamellæ somewhat triangular or crescent-shaped, with long black hairs, (N. Y., Mass.)...................................*lamellatus*, Loew.
25. Inner appendages of the hypopygium slender, with long branched bristles...26
Inner appendages with their hairs and bristles simple....................28
26. Hypopyginal lamellæ furcate, (Texas).......................*furcifer*, Loew.
Lamellæ entire, not at all forked..27
27. Hypopyginal lamellæ somewhat oval in outline, still obtusely pointed at tip; face with yellow pollen; see figures 14 and 15, (Ind., La.) *arboreus*, new species.
Lamellæ more sickle-shaped, quite acutely pointed at tip; face silvery white; see figures 16 and 17, (Va., Ind.).............*ramosus*, new species.
28. Face with brown pollen, (Louisiana).....................*proximus*, Aldrich.
Face with white pollen...29
29. Hypopyginal lamellæ narrow, gently bent upwards at tip, (Fla., Ga., La., D. C.)..*laetus*, Loew.
Lamellæ produced into a curved, stout, black, horn-like point, which is longer than the lamella, (Quebec)......................*falcatus*, Aldrich.
30. Fore coxæ blackened on basal half or more; hypopyginal lamellæ long....31
Fore coxæ wholly yellow, or nearly so.......................................32
31. Hypopyginal lamellæ rounded at tip, all their hairs black, (see figures 18 and 24), (N. America; Mexico)..........................*vagans*, Loew.
Lamellæ pointed at tip (fig. 25), their hairs largely yellowish, (Calif., Ore.)..*occidentalis*, Wheeler.
32. Hypopyginal lamellæ largely blackish......................................33
Lamellæ largely yellow or whitish; upper half of the hypopygium and its tip yellow...39
33. Upper half of face shining green...34
Face wholly opaque with pollen...35
34. Lamellæ of the hypopygium long and narrow with minute yellow appendages at base, between those and projecting beyond them are what seem to be the inner appendages; they are thick and shining black with a long black bristle at base, (W. I., Mex., Guatemala). *argentifer*, Aldrich.

Lamellæ as above; inner appendages formed as above, but yellow and without the bristle at base, still there is a bristle on their lower edge near the middle which is not found on the proceeding species, (Guatemala)....................................*caeruleus*, new species.
35. Thorax with a small glistening white dot in the sutural groove, (Eastern States, Mexico)....................................*cognatus*, Loew.
The white spot at the sutural groove larger, sometimes indistinct........36
36. Hypopyginal lamellæ long and strap-like....................................37
Lamellæ not at all strap-like....................................38
37. All coxæ yellow, still the middle and hind ones a little darkened at base, (Island of St. Jean)....................................*taeniatus*, Becker.
Fore coxæ yellow, a little blackened at base; middle and hind coxæ black with yellow tips; the long strap-like lamellæ have a very small, oval, yellow base which is fringed with small yellow hairs. Wing as in figure 20, (Cuba)....................................*insulanus*, new species.
38. Hypopyginal lamellæ short, rounded, (Florida).........*floridans*, Wheeler.
Lamellæ ax-shaped, (Georgia)....................................*asciaeformis*, Becker.
39. Antennal arista long, not tapering, its tip rather blunt, (Wis., Ill., N. Y., La.)....................................*neglectus*, Wheeler.
Arista normal, tapering to a fine point....................................40
40. Abdomen shining steel-blue; pollen of the face wholly white, (West Indies)....................................*fasciatus*, Roeder.
Abdomen green; upper half of face with its pollen almost golden yellow; wing as in figure 21, (Tex., Ga., Calif.)..................*wheeleri*, Melander.

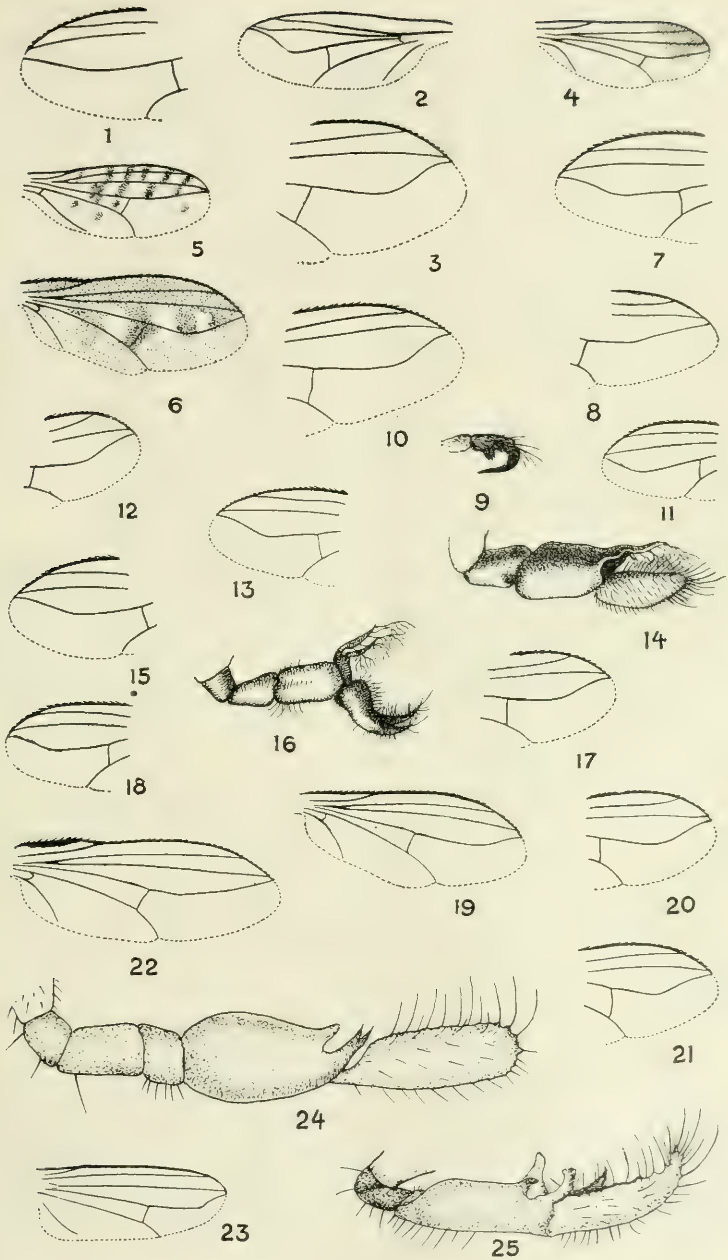
FEMALES.

1. Femora black, at least one pair largely black....................................2
Femora yellow, the tip or upper edge may be blackened....................3
2. Face with yellow pollen, which may be thin on upper portion; antennæ black, except the lower edge of first joint..............*hamatus*, Aldrich.
Pollen of the face brown, except a narrow line of white on each side; upper portion of face green in the center; antennæ mostly yellow. *aldrichi*, new species.
3. Wings with numerous spots or clouds in the cells..........................4
Wings with one to three spots, which are sometimes small and placed on the veins....................................5
Wings unspotted, but sometimes with the front margin more or less tinged with brown....................................7
4. Last section of fourth vein abruptly bent towards third, at a point beyond its middle, (fig. 6)....................................*pictipennis*, Wheeler.
Last section of fourth vein uniformly approaching third towards its tip, (fig. 5)....................................*punctipennis*, Say.
5. Wings with a faint cloud at tips of third and fourth veins (about as in figure 4); the usual silvery spot at the suture is yellow in this species *bigeminatus*, Aldrich.
Wings with a brown spot on the middle of the last section of the fourth vein and another on the cross-vein and near the root of the wing. *umbripictus*, Becker.
6. Fore coxæ black, at least considerably blackened at base..................7
Fore coxæ yellow; there may be a blackish spot at base on outer surface....18
7. Thorax with a more or less distinct spot of white pollen before the scutellum, best seen when viewed from behind..........................8
Thorax without such a spot of pollen....................................10
8. Last section of fourth vein rather abruptly bent near its middle, as in figure 7....................................*longicauda*, Loew.
Last section of fourth vein gently arched from the cross-vein to its tip, which is near the tip of third vein, about as in figure 8..................9
9. Antennæ yellow below....................................*unguiculatus*, Aldrich.
Antennæ wholly black....................................*dissimilipes*, Wheeler.
10. Orbital cilia pale below....................................11
Orbital cilia wholly black....................................12

11. Wing with the costa very conspicuously enlarged before the tip of the first vein, (fig. 22) .... *costalis*, new species.
Costa not at all thickened .... *occidentalis*, Wheeler; *vagans*, Loew.
12. Fore coxæ almost wholly black 13
Fore coxæ blackened at base nearly to the middle 16
Fore coxæ a little blackened at base in front, their outer surface nearly half blackish 17
13. Last section of fourth vein gently arched, not bent, about as in figure 8 14
Last section of fourth vein with a distinct bend, which is quite abrupt 15
14. Face brown, the brown reaching the lower edge, narrowly white on the sides .... *dissimilipes*, Wheeler.
The brown of the face shading into gray below, face broadly white on the sides .... *tibialis*, new species.
15. Bend in last section of fourth vein near its middle; base of fore femora usually infuscated, (eastern species) .... *abbreviatus*, Loew.
Bend in last section of fourth vein near its apical third, (western species). *cyaneus*, Wheeler.
16. Hind tibiæ largely infuscated; wing as in figure 11 .... *lugubris*, Loew.
Hind tibiæ wholly or almost wholly yellow .... *lamellatus*, Loew.
17. Bend in last section of fourth vein nearly three times as far from the cross-vein as the length of that vein .... *heteroneurus*, Macquart
Bend in last section of fourth vein at or very near its middle. *barbicauda*, new species.
18. Orbital cilia wholly black 19
Orbital cilia pale below 21
19. Face wholly covered with white pollen; wing as in figure 13 .. *parvus*, Aldrich.
Pollen of the face brown, except a narrow line of white along the orbits 20
20. Middle and hind coxæ with apical half yellow .... *proximus*, Aldrich.
Middle and hind coxæ with apical third yellow .... *falcatus*, Aldrich.
Middle and hind coxæ almost wholly black; wings as in figure 15. *arboreus*, new species.
21. Upper half of face concave, shining green with little pollen; lower half convex, opaque with grayish white pollen, which is more brown near the suture 22
Face wholly opaque with pollen, or nearly so 23
22. Inferior orbital cilia yellowish with one or two black bristles next to the proboscis .... *caeruleus*, new species.
Lower part of the head without a black bristle, those near the proboscis wholly yellowish .... *argentifer*, Aldrich.
23. Arista long, tapering but little, its tip blunt .... *neglectus*, Wheeler.
Arista normal, tapering to a point 24
24. Abdomen with the hind margins of the segments conspicuously blackened? .... *fasciatus*, Roeder.
Hind margins of the abdominal segments narrowly black as usual 25
25. Upper portion of the face with yellow pollen .... *wheeleri*, Melander.
Pollen of the face brown on the center, white on the sides 26
26. The brown pollen of the face reaches the lower edge, white pollen on the sides narrow; thorax with the sutural spot of white pollen large. *floridanus*, Wheeler.
The brown of the face narrow, and not reaching the lower edge; thorax with the sutural spot small, glistening white, round, dot-like *cognatus*, Loew.

EXPLANATION OF PLATE I.

Fig. 1. nigricornis, new species, tip of wing.
Fig. 2. hamatus, Aldrich (after Aldrich). Wing.
Fig. 3. aldrichi, new species, tip of wing.
Fig. 4. bigeminatus, Aldrich, (after Aldrich). Wing.
Fig. 5. punctipennis, Say. Wing.
Fig. 6. pictipennis, Wheeler. Wing.
Fig. 7. longicauda, Loew. Tip of wing.
Fig. 8. nigrifacies, new species, tip of wing.
Fig. 9. nigrifacies, new species, fifth joint of fore tarsus of male.
Fig. 10. cyaneus, Wheeler. Tip of wing.
Fig. 11. lugubris, Loew. Tip of wing.
Fig. 12. aurifacies, new species, tip of wing.
Fig. 13. parvus, Aldrich. Tip of wing.
Fig. 14. arboreus, new species, hypopygium of male.
Fig. 15. arboreus, new species, tip of wing.
Fig. 16. ramosus, new species, hypopygium of male.
Fig. 17. ramosus, new species, tip of wing.
Fig. 18. vagans, Loew. Tip of wing.
Fig. 19. cognatus, Loew. Tip of wing.
Fig. 20. insulanus, new species, tip of wing.
Fig. 21. wheeleri, Melander. Tip of wing.
Fig. 22. costalis, new species, wing.
Fig. 23. heteroneurus, Macquart. Wing, (after Macquart).
Fig. 24. vagans, Loew. Hypopygium of male.
Fig. 25. occidentalis, Wheeler, hypopygium of male.



M. C. Van Duzee

THE WAX SECRETING GLANDS OF PSEUDOCOCCUS CITRI RISSO.

By Robert Matheson,
Cornell University.

Wax secreting glands are found in a large number of insects scattered throughout the various orders. Though the secreted product varies greatly in composition and the uses very diverse yet, so far as known, all wax glands are epidermal in origin and usually more or less closely connected with the exterior. The most noted groups of wax producing insects are the Aphididæ and Coccidæ. So important is it in some of the Coccidæ that very large industries are based upon the product—i. e., lac produced by the lac insects (*Tachardia lacca*, *Gascardia* (*Ceroplastes*) *madagascarensis*, etc.). Lac is a resinous product which in the case of the *Gascardia* product consists of about 28.5% wax and 52.5% resin, while the lac of *Tachardia lacca* contains 68% resin and only 6% wax. The animal value of the Indian product now exceeds $20,000,000 and a great deal of experimental work is being done in the cultivation and improvement of the lac industry in India.

Wax production also occurs in other hemipterous families as Fulgoridæ, Cicadidæ, Notonectidæ, etc., in the Lepidoptera, (*Retinia* sp.), Coleoptera (Rhyncophora), and Hymenoptera (*Tenthredinidæ*, *Apidæ*, *Bombidæ*).

Our knowledge of the wax producing glands is very limited and consists of a few isolated papers written in various languages. Berlese (1893), Visart (1894 and 1895), and Sulc (1909) are the principal contributors on the wax glands of Coccidæ and Aphididæ. As this paper does not deal with wax glands in general, I shall restrict myself to a discussion of the glands as found in Coccidæ, more particularly *Pseudococcus* species. In discussing the various types of glands reference will be made to the work of the above mentioned authors, especially where I differ from them in the interpretation of structure and types of glands.

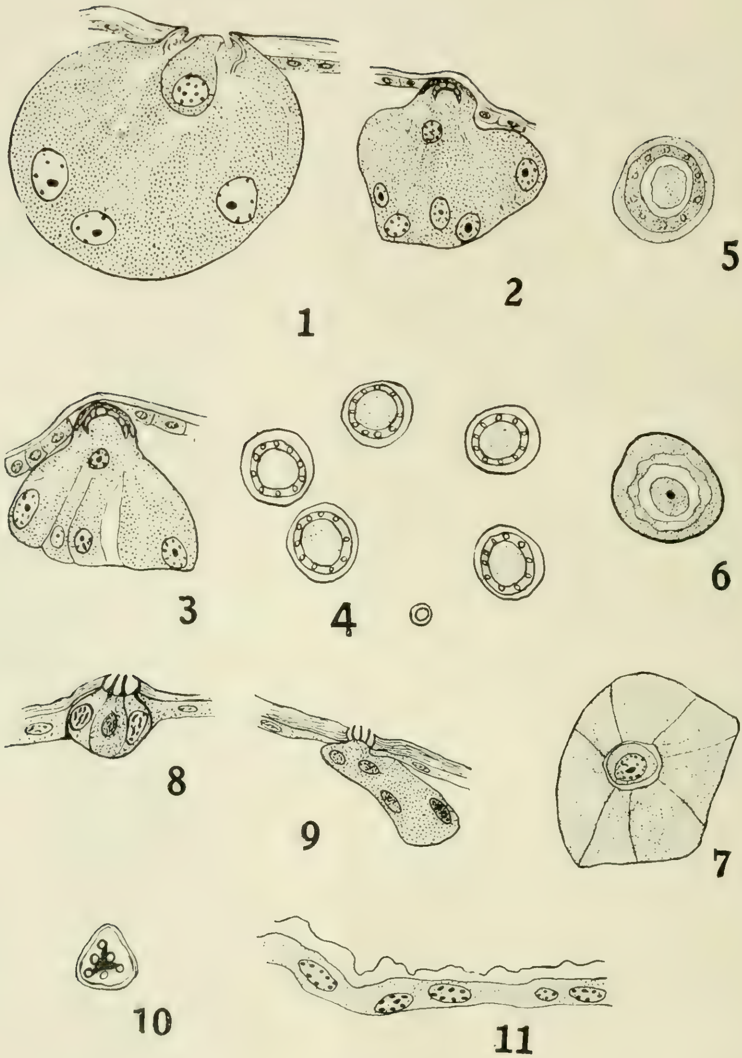
Pseudococcus citri, one of the common species of mealy bugs, is well known. The name mealy bugs undoubtedly refers to the mealy, waxy secretion which covers the entire body, and extends in beautiful lateral and caudal pencils. In this species there are seventeen such pencils, three on the head, two on each thoracic segment and one on each of the eight abdominal segments. In addition to these pencils the entire body is covered by a fine waxy powder and the females produce a loose waxy filamentous sac in which the eggs are laid. All this wax and waxy threads are produced by various types of epidermal wax glands. Fig. 11 shows the normal epidermal structure.

THE WAX GLANDS.

There are several distinct types of wax glands. I shall discuss each type separately and endeavor to indicate the precise product produced by each type.

TYPE I. This is a large, multicellular gland. (Figs. 1, 2, 3). It is found most abundant on the posterior ventral and lateral portions of the body, particularly about the opening of the oviduct. It also occurs around the cerarii and scatteringly over the ventral and lateral margins of the body. Viewed in toto this gland appears shaped like an erlenmyer flask with a short neck. The number of cells composing it undoubtedly varies though it would seem to run from seven to eleven. There is always a central cell which forms a sort of stopper and around which the others are arranged. The external opening of this gland is rather remarkable. Viewed from the external it is a circle, a chitinous ring, through which a number (usually 10) openings are found (Fig. 4). The center of this ring is closed by the cuticula of the central cell. In sections the minute pores can be traced directly back into the cells and undoubtedly they are the exits for the secretion. In actively secreting cells these pores gradually enlarge as we proceed into the gland. This condition is well shown in Figs. 5, 6 and 7.

As this type of gland is very abundant about the genital opening they undoubtedly secrete much of the waxy threads which form the egg sac. The type of thread they secrete, in the writer's opinion, is shown in Fig. 20. (The short coiled threads.)



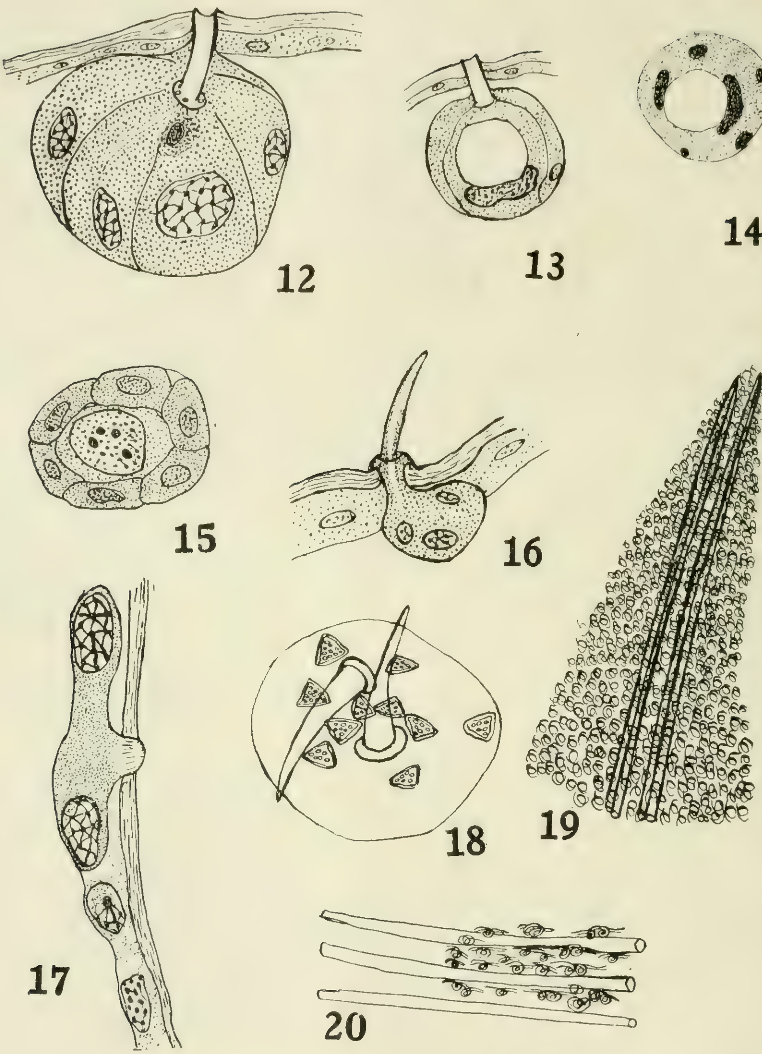
Robert Matheson

Type II. This gland is even more remarkable than the preceding. It does not occur in such abundance, but is always found associated with it. It also resembles a flask, but with a long chitinous neck and an entirely different type of external opening. Like the former it always possesses a central cell closely associated with the exit tube (Fig. 12). The exit tube is a chitinous cylinder extending down into the gland. According to Visart (1894) the proximal end of the tube is closed. The external opening is a minute circle appearing in the chitin (Fig. 4, the small figure). This gland is composed usually of from six to ten cells. It is supposed to secrete the long, large threads of the lateral filaments and the ovisac. Visart states that the contents of the cells pass through this chitinous cylinder where it hardens and then passes out as a thread. I do not agree with this. I have been able to demonstrate again and again minute pores around the base of this chitinous cylinder. I believe the secretion of these cells is poured through these pores and the cylinder forms the mold in which the thread takes shape. It is gradually pushed to the exterior by the pressure behind. Within the cylinder the secretion hardens into a thread so that the excreted product is a continuous flexible thread. When this gland is secreting actively a large central area is filled with the product (Figs. 13 and 14) and the wax thread can be seen in sections extruding from the external opening.

This gland is always associated with Type I, but is not so abundant.

Type III. This is a much smaller gland and is found all over the insect. Like the others, it consists of a central cell surrounded by several cells (Figs. 8 and 9). It lies close in the hypodermis and possesses a prominent external opening. These openings appear as triangular areas with a rather heavy chitinous Y-like centre surrounded by minute pores (Fig. 10). In longitudinal section the gland and its opening appears as in Fig. 8. These glands secrete the small, short, coiled wax threads found covering the entire body and mingled in the filaments. They are not present immediately surrounding the genital opening.

This type of gland is found in all the cerarii, closely investing the two spines (Fig. 18).



Robert Matheson

Type IV. This type is a very small gland always associated with a minute spine. It consists of three or four cells and lies almost as shallow as the hypodermis (Fig. 16). Studying the gland under high magnification there can be distinguished in most cases the prolongation of the cell cytoplasm directly to and into the spine itself. Within this narrow cylinder of cytoplasm can be seen plainly a minute duct which I believe opens at the tip of the spine. What the particular function of this type of gland may be or the kind of material secreted I have no means of determining. These glands are scattered over the body of the insect.

Type V. Scattered here and there may be found rather peculiar one and two celled glands (Fig. 17). I have been unable to determine the exact type of external opening of this gland and am still in doubt whether it is an actual gland or the beginning of one of the other glandular types. Visart (1896) states that he observed direct nuclear division in some of the glandular cells, but so far I have been unable to demonstrate such division.

WAX SECRETION.

Glands of Type II secrete the long straight threads that are found abundantly in the ovisac and a few, usually four, in the lateral filaments. Examination of the material in the ovisac shows it to be composed exclusively of two kinds—the long threads and a mass of short coiled threads attached to the long threads and about the eggs (Fig. 20). The short coiled threads are secreted by Type I and this type of gland is very abundant on the venter near the opening of the vagina. The long threads measure on the average from 2 to 2.5 microns in diameter, and this corresponds identically with the diameter of the neck of Type II gland.

The wax composing the lateral filaments is of interest. In each filament there appears two threads close to each other and these are surrounded by a mass of longer and shorter coiled threads (Fig. 19). On examination the two central threads are each found to be composed of two threads closely applied to each other. In diameter they measure 5 microns. Each set arises from two glands of Type II, situated close together near the cerarius. The threads issuing from these glands

become fused and thus form the supporting framework for the filament. Surrounding and between these threads is a very large mass of coiled wax threads. These coiled wax threads arise from Type I and the very short ones from Type III. Type III is found abundantly about each cerarius.

The general waxy covering of the body is composed of short coiled threads arising from glands of Type III. These glands are found very abundant all over the body of the insect.

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UNDESCRIBED SPECIES OF JAPANESE CRANE-FLIES (Tipulidae, Diptera.)

Part III.

By Charles P. Alexander.

The first two parts under this general title were published in these Annals in 1919 and 1921. Virtually all of the species included in the present report were sent to me for determination by Dr. Shiraki and were collected by himself and other entomologists, Messrs. Inamura, Isshiki, Issiki, Miyake, Okuni, Sonan and Yoshino. Additional material was sent by Dr. Machida. The writer's thanks are extended to all of these gentlemen for their co-operation in making known the large and very important Tipuloidean fauna of the Japanese Empire. Where not stated to the contrary, types of the novelties described herein are preserved in the collection of the writer.

Dicranomyia Stephens.

Dicranomyia (Idioglochina) kotoshoensis sp. n.

General coloration brownish yellow; head gray; mesonotal praescutum with three brown stripes; wings pale brown; *Sc* very short; *Rs* shorter than the deflection of R_{4+5}; veins R_1, R_{2+3} and R_{4+5} generally parallel to one another, straight.

Male—Length, about 5.5 mm.; wing, 5.6 mm.

Rostrum brown, the palpi dark brown. Antennæ dark brown; flagellum with the structure of the species of the subgenus, the verticils being very stout, almost spinous, arranged in a row around the periphery of the segment. Head gray.

Mesonotum yellowish pollinose with three broad, brown stripes, the median stripe becoming indistinct before the suture; scutal lobes brown, the median area paler; scutellum injured in pinning, apparently sparsely pruinose; postnotum brown, paler basally. Pleura brownish yellow with a sparse, microscopic gray pubescence. Halteres pale, the knobs slightly darker. Legs with the coxæ concolorous with the pleura; trochanters obscure yellow; femora obscure brownish yellow; tibiæ and tarsi brown; claws toothed. Wings pale brown; stigma barely indicated; veins brown. Venation: *Sc* short, Sc_1 ending far before the origin of *Rs*, this distance longer than the basal deflection of Cu_1, Sc_2 a short distance from the tip of Sc_1, the latter about equal to *m;* *Rs* very short, about two-thirds the deflection of R_{4+5}; R_{2+3} straight,

parallel to R_1; *r* very indistinct, at the tip of R_1; deflection of R_{4+5} arcuated, a little shorter than the basal deflection of Cu_1; outer section of R_{4+5} generally parallel with R_{2+3}; cell *1st* M_2 long, irregularly pentagonal, longer than any of the veins beyond it; basal deflection of Cu_1 just beyond the fork of *M*, about equal to Cu_2. Anal angle of wing conspicuous, as in subgenus.

Abdomen light brownish yellow, the basal tergites darker brown; hypopygium obscure yellow. Male hypopygium (described from the dry type only) with the pleurites comparatively long and slender, the proximal face at the base with a large, subglobular lobe that is provided with abundant, long, erect setæ; the two appendages are closely approximated, the outer hook stout, the inner fleshy appendage a little longer than the chitinized hook, terminating in a rather blunt, unarmed beak. Penis-guard conspicuous.

Habitat: Japan (Taiwan). Holotype, ♂, Island of Kotosho, March 15–April 10, 1920 (T. Okuni and J. Sonan). Type in the collection of the Agricultural Experiment Station, Taihoku.

Dicranomyia kotoshoensis is of unusual interest as being the first Oriental species of the subgenus *Idioglochina* Alexander to be described, the three species previously known being from the Australasian region (Waigeou to N. Queensland).

(?) **Dicranomyia shirakii** sp. n.

General coloration dark with a marmorate pattern of microscopic gray pubescence; legs yellow, the femoral tips, tibial bases and tips dark brown; wings whitish subhyaline with a heavy brown pattern, including five very extensive costal blotches; *Sc* ending opposite the origin of *Rs*, Sc_2 lacking; basal deflection of Cu_1 before the fork of *M*.

Male—Length, excluding head, 5 mm.; wing, 6.5 mm.

Head lacking.

Pronotum brown, marmorate laterally with gray pruinose. The thoracic pattern is more or less destroyed by verdigris and can be discussed in general terms only; mesonotal praescutum light gray pruinose with a broad, black, median stripe that is sparsely provided with golden yellow pollen; remainder of the mesonotum dark brown with a microscopic, appressed pubescence that appears as a sparse pruinosity. Pleura dark brown, handsomely marmorate with a silvery gray, microscopic pubescence; dorso-pleural membrane obscure yellow. Halteres white, the large knobs conspicuously dark brown. Legs with the coxæ brown, sparsely gray pubescent; trochanters obscure yellow; femora slender, bright yellow, the tips rather broadly and conspicuously dark brown; tibiæ brownish yellow, the bases and tips narrowly dark brown; tarsi dark brown. Wings whitish subhyaline with a heavy brown pattern; costal region with five very extensive brown blotches, the first at the level of the arculus, including both cells *C* and *Sc* and sending a cloud over arculus; second blotch near mid-distance between

arculus and the origin of *Rs*, sending a quadrangular cloud into cell *R;* third blotch above the end of *Sc* and origin of *Rs*, sending a rectangular cloud over the base of *Rs;* fourth blotch at stigma, sending a large cloud over the fork of *Rs*, separated from the fifth and apical blotch only by a large, rounded spot of the ground color in the base of cell *2nd* R_1; apical blotch includes more than the distal half of cell *2nd* R_1 and all of R_3 except a series of about six indistinct whitish spots; the white interspaces between the first three blotches do not equal more than one-fifth the blotch in extent; besides the above brown areas, the remainder of the cord and outer end of cell *1st* M_2 is broadly seamed with brown; paler brown clouds occupy most of cells *2nd* M_2, M_3, *Cu* and *M*, the base and outer ends of cells Cu_1, *1st A* and *2nd A*, there being large hyaline areas in the outer ends of cells *Cu*, *1st A* and *2nd A*, the brown clouds confined to the ends of the veins; veins dark brown, pale in the hyaline areas. Venation: Sc_1 ending opposite the origin of *Rs*, Sc_2 lacking; *Rs* gently arcuated, about twice the deflection of R_{4+5}; *r* at tip of R_1; deflection of R_{4+5} longer than the basal deflection of Cu_1; cell *1st* M_2 rectangular, almost as long as vein M_{1+2} beyond it; basal deflection of Cu_1 about one-half its length before the fork of *M;* vein *2nd A* gently bisinuous.

Abdomen brown, the hypopygium obscure yellow.

Habitat: Japan (Taiwan). Holotype, ♂, Tappan, altitude about 3,000 feet, June 18, 1917 (T. Shiraki). Type in the collection of the Agricultural Experiment Station, Taihoku.

?Dicranomyia shirakii is a very conspicuous crane-fly whose true generic position is rendered somewhat doubtful by the loss of the head of the type. It is almost certainly a *Dicranomyia*, but there is a possibility of its being a *Geranomyia* or a *Rhipidia*. It is named in honor of the collector, Dr. T. Shiraki, to whom I am indebted for many favors.

Dicranomyia subumbrata sp. n.

General coloration obscure yellow; head gray; pleura with a broad, dark brown stripe; wings tinged with brown; stigma, a spot at origin of *Rs* and conspicuous seams along the cord and outer end of cell *1st* M_2 seamed with brown; *Sc* long, cell *1st* M_2 closed; abdominal segments brown, paler basally; male hypopygium large and complex.

Male—Length about 5.5 mm.; wing, 6.2 mm.

Female—Length about 6 mm.; wing, 6.3 mm.

Rostrum and palpi dark brown. Antennæ dark brown, the flagellar segments oval-cylindrical. Head gray.

Mesonotal praescutum obscure yellow, the posterior median area broadly dark brown; lateral stripes obliterated; scutal lobes dark brown, the median area yellowish; remainder of the mesonotum brown. Pleura obscure yellow with a conspicuous, dark brown stripe extending from the cervical sclerites, beneath the halteres, to the abdomen. Halteres

brown, the base of the stem obscure yellow. Legs with the coxæ and trochanters obscure yellow; remainder of the legs dark brown, the femoral bases paler. Wings tinged with brown; stigma conspicuous, dark brown, circular in outline; a large paler brown spot at origin of Rs; seams along the cord, outer end of cell *1st* M_2 and at the tip of Sc_1, brown; veins dark brown. Venation: Sc_1 ending just beyond mid-length of Rs, Sc_2 at its tip; Rs slightly angulated at origin; r at tip of R_1 and at about one-third the length of R_{2+3}; cell *1st* M_2 closed, the basal deflection of Cu_1 at the fork of M.

Abdomen dark brown, the tergites narrowly pale basally; sternites yellow, ringed caudally with brown. Male hypopygium large and complicated in structure; pleurites short and stout, the meso-caudal angle produced mesad into a long arm, the margin of which is provided with a ledge set with microscopic spinulæ; pleural appendages much smaller than the pleurite, consisting of an outer chitinized hook and two inner, fleshy, curved lobes, the more proximal being bent at a strong angle. Penis-guard large; gonapophyses broad-based, the acute, slender tips directed strongly laterad, before the tip with close parallel ridges. Ovipositor with the tergal valves slender, strongly curved.

Habitat: Japan (Taiwan). Holotype, ♂, Horisha, December 20, 1916 (T. Shiraki). Allotopotype, ♀. Type in the collection of the Agricultural Experiment Station, Taihoku.

Dicranomyia subumbrata is related to the smaller *D. umbrata* de Meijere (Java), differing in the coloration of the abdomen, the hypopygial structure, and other characters.

Limonia Meigen.

Limonia nigronitida sp. n.

Head and thorax shiny black, the thoracic pleura with a microscopic, appressed, gray pubescence; halteres yellow; legs black, fore and hind femora with a narrow, yellow, subterminal ring; wings light yellow, spotted and clouded with brown; stigma large, oval, dark brown; r near the tip of R_1; basal deflection of Cu_1 before the fork of M; abdomen orange on basal half, black on the terminal half.

Male—Length, 11.5 mm.; wing, 12.5 mm.

Rostrum and palpi dark brownish black. Antennæ with the scape black, the flagellum dark brown throughout. Head shiny brownish black, the anterior part of the vertex and a narrow margin along the eyes with an appressed gray pubescence.

Pronotum elongate, black, the scutellum shiny dark brown. Mesonotum shiny black, the median area of the scutum and the scutellum very sparsely gray pubescent. Pleura black with a heavy appressed gray pubescence. Halteres pale yellow. Legs with the fore and middle coxæ dark brown, the posterior coxæ more shiny reddish, brown posteriorly; trochanters obscure yellow; femora black, rather narrowly

obscure yellow basally, before the black tip with a narrow yellow ring, this subobsolete on the mid-femora; remainder of the legs black. Wings light yellow, the base and cells *C* and *Sc* brighter yellow; stigma large, oval, dark brown; conspicuous rounded brown spots at origin of *Rs* and the deflection of R_{4+5}; an extensive paler brown wash at the wing-apex, occupying the outer ends of cells *2nd* R_1, R_3, the middle portion of R_5, *2nd* M_2 and M_3, the outer ends of these latter being pale; large, triangular pale brown clouds at ends of veins Cu_2 and *1st A;* cord and outer end of cell *1st* M_2 narrowly seamed with dark brown; a pale brown seam along the margin of cell *2nd A;* veins dark brown, paler in the flavous areas. Venation: Sc_1 ending beyond the fork of *Rs*, Sc_1 about twice *Sc2; Rs* angulated at origin; *r* about one and one-half its length from the tip of R_1; inner ends of cells R_3 and *1st* M_2 lying far proximad of cell R_5; basal deflection of Cu_1 before the fork of *M*.

Abdomen with the basal four segments obscure, light orange, unmarked, the remainder of the abdomen, including the hypopygium, shiny black, only the penis-guard and pleural appendages of the hypopygium a little paler.

Habitat: Japan (Hokkaido). Holotype, ♂, Teshio, July 4, 1916 (T. Isshiki). Type in the collection of the Agricultural Experiment Station, Taihoku.

Limonia nigronitida is not closely related to any of the four described European species with shiny black head and thorax (*pannonica* Kowarz, *nitida* Verrall, *splendens* Kuntze and *proxima* Kuntze). No American species of this group have been discovered.

Rhipidia Meigen.

Rhipidia (Rhipidia) rostrifera formosana subsp. n.

Male—Length about 5 mm.; wing, 5.5 mm.

Generally similar to *R.* (*R.*) *rostrifera* Edwards of the Malay Peninsula and Sumatra, differing as follows:

Mesonotal praescutum yellowish gray with three conspicuous dark brown stripes; median stripe broad, indistinctly split longitudinally by a pale line; lateral stripes conspicuous; scutal lobes with the centers dark brown; scutellum gray pruinose. Pleura gray with a narrow, longitudinal brown stripe ending beneath the root of the halteres. Mesosternum dark brown, the dorsal margin sharply delimited. Femora brown with a conspicuous, broad, darker brown, subterminal ring, the extreme tip narrowly pale. Wings with the brown pattern extensive, the outer costal blotch including the distal fourth of cell *2nd* R_1 and the distal two-fifths of cell R_3; stigmal blotch quadrate, confluent with the oval costal blotch at tip of *Sc*. Venation: Sc_2 lacking, the subcostal cross-vein present and surrounded by a small brown cloud; *Rs* elongate, strongly arcuated at origin; cell M_3 comparatively small, about one-half

the length of its petiole; basal deflection of Cu_1 beyond the fork of M, the distance a little shorter than $r\text{-}m$, Cu_2 being shorter than the deflection of Cu_1.

Habitat: Japan (Taiwan). Holotype, ♂, Funkiko, altitude about 6,000 feet, April 29, 1917 (T. Shiraki). Type in the collection of the Agricultural Experiment Station, Taihoku.

Gonomyia Meigen.

Gonomyia (Progonomyia) scutellum-album sp. n.

General coloration black; pronotal and mesonotal scutella whitish yellow; pleura dark brown, the epimeron yellow; knobs of the halteres light yellow; wings faintly tinged; Sc_1 ending about opposite two-thirds *Rs;* penis-guard very large and flattened near mid-length, the apex suddenly narrowed, acicular.

Male—Length about 4.5 mm.; wing, 6.6 mm.

Female—Length about 4 mm.; wing, 6.3 mm.

Rostrum and palpi dark brown. Antennæ dark brown, the segments oval. Head black, rather sparsely dusted with light gray.

Pronotum dark brown, the scutellum conspicuously light yellow. Mesonotum black, the scutellum conspicuously and abruptly whitish yellow. Pleura dark brown, the epimeron yellow. Halteres brown, the knobs conspicuously light yellow. Legs with the coxæ and trochanters dark brown; remainder of the legs dark brownish black. Wings with a faint brownish tinge, the stigma barely indicated; veins dark brown. Venation: Sc_1 ending about opposite two-thirds the length of *Rs*, Sc_2 far from the tip of Sc_1, closer to origin of *Rs* than to tip of Sc_1; *Rs* long, straight; *r* lacking; petiole of cell *2nd* M_2 about one-half longer than the basal deflection of Cu_1, the latter about one-third its length beyond the fork of M.

Abdominal tergites brown, the caudal margins of the segments rather broadly dark brown. Hypopygium paler brown, more nearly concolorous with the sternites. Male hypopygium with the lateral angle of pleurite a little produced; three pleural appendages; outer appendage pale, gradually narrowed apically; middle appendage cylindrical at base, near mid-length dilated into a collar, the lateral margin jutting out into a black lobe, the apical two-fifths very slender, gently curved; inner pleural appendage the shortest, the proximal face with long setæ. Penis-guard very large and highly compressed, slender basally, dilated into a roughly oval blade from the end of which the long, slender, needle-like extension of the guard continues, bent strongly near its origin and lying nearly parallel with the margin of the dilation.

Habitat: Japan (Taiwan). Holotype, ♂, Funkiko, altitude about 6,000 feet, April 21, 1917 (T. Shiraki). Allotopotype, ♀. Type in the collection of the Agricultural Experiment Station, Taihoku.

Gonomyia scutellum-album is related to *G. strenua* (Brunetti). It would seem better to refer both species to the subgenus *Progonomyia* of *Gonomyia* Meigen, although they differ somewhat from the characteristic form of the group.

Teucholabis Osten Sacken.

Teucholabis aberrans sp. n.

Head dark gray; mesothorax shiny reddish; wings tinged with brown, more saturated along costa; cell *2nd* M_2 with a short petiole; abdomen brownish black.

Male—Length, 7 mm.; wing, 6.5 mm.

Rostrum nearly as long as the remainder of the head, shiny black; palpi dark brownish black. Antennæ dark brownish black throughout. Head dark gray.

Pronotum reddish. Mesothorax entirely shiny reddish. Halteres dark brown. Legs with the fore and middle coxæ obscure reddish, the hind coxæ dark brown; trochanters dark brown; remainder of the legs broken. Wings strongly tinged with brown, darkest along the costal margin to the end of vein R_{2+3}; veins dark brown. Venation: Sc_1 ending about opposite three-fourths the length of Rs, Sc_2 at about three-fifths the distance between the origin of Rs and the tip of Sc_1; Rs long, nearly straight; r on R_{2+3} about its own length beyond the fork; cell *1st* M_2 elongate, the sides parallel; cell *2nd* M_2 with a short petiole that is a little longer than r–m; basal deflection of Cu_1 a little less than its own length beyond the fork of M.

Abdomen shiny brownish black, only the incisures of the terminal segments narrowly silvery.

Habitat: Japan (Taiwan). Holotype, ♂, Island of Kotosho, March 15–April 10, 1920 (T. Okuni and J. Sonan).

Teucholabis aberrans differs from all other described species by the petiolate cell *2nd* M_2. In its general appearance it suggests *T. inornata* Riedel.

Elephantomyia Osten Sacken.

Elephantomyia (Elephantomyodes) major sp. n.

General coloration light yellowish brown, the thoracic pleura brighter; legs black, the terminal tarsal segments snowy white; wings tinged with brown; cells Sc, Sc_1 and the outer end of R_1 dark brown; abdominal segments indistinctly bicolorous.

Male—Length (excluding rostrum), 11.5 mm.; wing, 10.4 mm.

Rostrum slender, black, if bent backward extending to about mid-length of the abdomen. Antennæ with 14 segments, the basal segment greenish testaceous, the remainder black with elongate flagellar verticils. Front surrounding the insertion of the rostrum with a greenish yellow

tinge. Head brown, narrowed posteriorly; vertex between the eyes about as wide as the first scapal segment.

Mesonotum light yellowish brown without markings, the scutellum slightly more testaceous; postnotum narrowly and indistinctly darker brown medially. Pleura obscure yellow, the propleura darker; mesosternum more pruinescent laterally. Halteres pale, the knobs brown. Legs with the coxæ obscure yellow, the fore coxæ darker; trochanters obscure yellow; femora black, the bases narrowly paler; tibiæ black; metatarsi black, the narrow distal end and the remaining tarsal segments except the last, snowy-white. Wings with a brownish tinge; cells *Sc*, Sc_1 and the narrow outer end of R_1 dark brown; veins dark brown. Venation: *Rs* strongly arcuated at origin; veins Cu_2 and *1st A* widely separated at wing margin, the distance much longer than the basal deflection of Cu_1; vein *2nd A* comparatively short.

Abdomen dark brown, segments three to five with the basal half pale brown; segment six similar but the basal half even brighter, yellowish brown; remainder of abdomen dark brown, the small hypopygium a little brighter.

Habitat: Japan (Taiwan). Holotype, ♂, Island of Kotosho, March 15–April 10, 1920 (T. Okuni and J. Sonan). Type in the collection of the Agricultural Experiment Station, Taihoku.

Elephantomyia major is related to *E. fuscomarginata* Enderlein (Sumatra), from which it is distinguished by its larger size, coloration, and the details of venation, especially the wide separation of veins Cu_2 and *1st A* at the wing-margin. This section of the genus now includes seven species in the East Indies and North Australia, differing from *Elephantomyia* s. s. by the lack of tibial spurs and the details of venation, *Rs* being in alignment with the deflection of R_{4+5}, and R_{2+3} arising almost perpendicularly from the end of the sector. This group of Elephantomyiæ with spurless tibiæ should receive subgeneric rank and the name *Elephantomyodes* may be used, *E. major* being the type of this section.

Epiphragma Osten Sacken.

Epiphragma divisa sp. n.

Allied to *E. vicina* Brunetti; legs uniformly light yellow; wing-pattern very restricted, the band along the outer end of cell *1st* M_2 isolated from the basal pattern.

Male—Length about 8 mm.; wing, 8.2 mm.

Female—Length, 11 mm.; wing, 10.5 mm.

Rostrum pale, golden-yellow pubescent; palpi dark brown. Antennæ with the scapal segments dark brown, the long first flagellar segment light yellow; second segment yellowish brown; remaining flagellar

segments uniformly brown. Head brown, obscure yellow adjoining the inner margin of the eyes; vertex with a low tubercle.

Pronotum dark brown. Mesonotal praescutum rich fulvous, passing into dark brown behind; remainder of mesonotum dark brown, the base of the scutellum gray pruinose. In the female, the mesonotum is provided with a light gray bloom that almost conceals the fulvous ground color. Pleura dark with patches of pruinescence and yellow pollen, the more dorsal sclerites grayish; ventral and posterior sclerites with a sparse yellow pollen. Halteres pale brown, the apices of the knobs light yellow. Legs with the coxæ obscure yellow, the outer face of each slightly infuscated; remainder of the legs light yellow, the femora immaculate. Wings comparatively narrow, much narrower than in *E. insignis* Wulp or *E. subinsignis* Alexander; subhyaline with a restricted brown pattern arranged somewhat as in *E. vicina* Brunetti, but even more broken, the pale areas more extensive; the large brown oblique band that crosses the outer end of cell *1st* M_2 is quite compact and isolated from the other markings, more or less Y-shaped, one arm of the Y reaching the margin at R_2, the other, broader, at R_{4+5} and M_1. Venation: *Rs* strongly angulated at origin; R_{2+3} comparatively short, about one-half longer than the deflection of R_{4+5}; cell *1st* M_2 large, in the female with *m* long and sinuous; petiole of cell M_1 only about one-half the cell, in the female longer than in the male; basal deflection of Cu_1 before one-fourth the length of the cell.

Abdominal tergites light brown, the margins of the segments darker brown; hypopygium dark brown.

Habitat: Japan (Taiwan). Holotype, ♂, Shinchiku, altitude 500–1,000 feet, July 1–30, 1918 (J. Sonan and K. Miyake). Allotype, ♀, Musha, altitude about 3,700 feet, May 18–June 15, 1919 (J. Sonan, K. Miyake and M. Yoshino). Types in the collection of the Agricultural Experiment Station, Taihoku.

Limnophila Macquart.

Limnophila (Lasiomastix) macrotrichiata sp. n.

Generally similar to *L. flavella* Alex.; size larger; head light gray; no dark spot at wing-root; wings pale yellow, the stigma conspicuous, oval, pale brown; macrotrichiæ of wing veins and membrane very long and conspicuous; cell *1st* M_2 rectangular.

Male—Length about 6.8 mm.; wing, 8 mm.

Rostrum obscure yellow; palpi brown. Antennæ short, the first scapal segment elongate; scape and basal three flagellar segments obscure yellow, the remainder of the flagellum dark brown. Head light gray with proclinate yellow bristles.

Pronotum dark medially, pale laterally. Mesonotal praescutum shiny, obscure brownish yellow without markings; scutellum and postnotum a little clearer yellow. Pleura pale brown with a sparse, microscopic, gray pubescence to produce the effect of a pruinosity.

Halteres pale, the knobs a little darker. Legs with the coxæ light brown, gray pubescent like the pleura; trochanters yellow; remainder of the legs obscure yellow, the tibial tips a little darkened; tips of the metatarsi and remaining tarsal segments pale brown. Wings with no black spot at base; pale yellow with a conspicuous, oval, pale brown stigma; cord faintly seamed with brown; macrotrichiæ of both veins and membrane very large, distinctly larger than in the other described Japanese species of the subgenus, conspicuous even with a hand-lens; these trichiæ occupy all but the bases of cells *2nd* R_1, R_2, R_3, R_5, M_1 and *2nd* M_2 and because of their size appear to almost fill the cells; outer ends of cells Sc_1, M_3 and Cu_1 likewise provided with these long setæ. Venation: Similar to *L. flavella saitamæ* Alex., differing as follows: *Rs* longer and less arcuated at origin; *r* closer to tip of R_1 than to origin of R_2; cell M_1 about twice its petiole; cell *1st* M_2 rectangular, the basal deflection of Cu_1 near one-third its length; vein *2nd A* longer, gently sinuous near outer end.

Abdomen brown. Male hypopygium as in *L. f. saitamæ*, differing in the details of structure; what seems to be the ninth tergite has a very deep U-shaped notch with the lateral lobes much broader than the notch, their tips very obtusely rounded; inner pleural appendage with the inner arm more than one-half the length of the clavate outer arm and more appressed to it.

Habitat: Japan (Hokkaido). Holotype, ♂, Teshio, July 3, 1916 (T. Isshiki). Type in the collection of the Agricultural Experiment Station, Taihoku.

Limnophila (Dicranophragma) taiwanensis sp. n.

Male—Length, 5.5 mm.; wing, 6.4 mm.

Most closely related to *L.* (*D.*) *multipunctipennis* Brunetti (N. India), differing as follows:

Size smaller. Antennæ with the first segment dark brown, the subglobular second segment light brown; first flagellar segment conspicuously yellow; remainder of the flagellum dark brown. No dark median line on head. Mesonotal praescutum obscure yellow pollinose, the space between the median and lateral stripes capillary, brown; a circular brown spot occupying the lateral margin of the praescutum caudad of the pseudosutural foveæ. Wings with the five large costal areas relatively small and insignificant; basal blotch occupies only cells *C* and *Sc;* stigma oval, the extension of it along the cord much paler and more or less interrupted; wing-tip not uniformly darkened; a brown seam at the strongly curved tip of vein *2nd A;* the numerous dots in the cells are not at all dash-like, but subcircular in outline. Venation: Cell *1st* M_2 larger, longer than broad, with the basal deflection of Cu_1 at three-fifths its length; petiole of cell M_1 longer than the cell. Abdomen dark brown, the bases of the elongate pleurites of the male hypopygium obscure yellow.

Habitat: Japan (Taiwan). Holotype, ♂, Taito, altitude about 500 feet, February 25–March 27, 1919 (S. Inamura, J. Sonan and M. Yoshino). Type in the collection of the Agricultural Experiment Station, Taihoku.

Limnophila taiwanensis is very distinct from the two insular species, *L.* (*D.*) *remota* (Meijere) of Java, and *L.* (*D.*) *formosa* Alexander, of Formosa.

Eriocera Macquart.

Eriocera geminata sp. n.

Related to *E. hilpa* (Walker); mesonotal praescutum velvety black with three shiny blue-black stripes; femora yellow, the tips narrowly dark brown; wings dark brown with a yellow blotch before and another beyond the origin of *Rs* in cell *R;* a white oval blotch before the cord in cells *R* and *M;* abdominal tergites velvety black, the bases broadly glabrous with pearly blue reflexions.

Male—Length about 11.5 mm.; wing, 9.5 mm.

Rostrum and palpi black. Antennæ black, setaceous, if bent backward, extending about to the base of the abdomen. Head black; vertical tubercle inconspicuous.

Mesonotum opaque, velvety black, the praescutum with three shiny, blue-black stripes; centers of the scutal lobes shiny. Pleura black. Halteres black. Legs with the coxæ and trochanters black; femora yellow, the tips narrowly dark brown; tibiæ and tarsi dark brown. Wings dark brown; cells *C* and *Sc* paler. Anal cells paler grayish brown, broadly suffused along vein *2nd A;* two conspicuous elongate, yellow blotches in cell *R*, one before and one beyond the origin of *Rs;* a conspicuous, white, oval blotch before the cord, lying just before the outer ends of cells *R* and *M*, barely extending across the sector into cell *1st* R_1; veins dark brown. Venation: *r* on R_2 about its length beyond the fork of R_{2+3}; R_{2+3} a little longer than the deflection of R_{4+5}; cell M_1 lacking; basal deflection of Cu_1 just beyond midlength of cell *1st* M_2.

Abdominal tergites glabrous basally, with pearly bluish reflexions; caudal margins broadly velvety black, this margin on the intermediate segments occupying about the distal third of the segment; sternites velvety black, only the bases narrowly glabrous. Hypopygium black.

Habitat: Japan (Honshiu). Holotype, ♂, Island of Oshima, Tokyo-Fu, July 16, 1918 (T. Shiraki); Collector's No. 6979. Type in the collection of the author; additional specimens in the collection of Dr. Shiraki.

Eriocera fulvibasis sp. n.

General coloration black; antennæ short; mesonotal praescutum light gray with three dark brown stripes, the median stripe broadly split by a plumbeous line; femora fulvous yellow, the tips broadly

blackened; wings yellow, the stigma dark brown; veins broadly seamed with paler brown; abdomen black, the lateral margins of the intermediate tergites rather narrowly buffy fulvous.

Male—Length, 17 mm.; wing, 15.4 mm.

Rostrum and palpi black. Antennæ short, ending a little before the wing-root, brownish black. Head brownish black.

Mesonotal praescutum light gray with three dark brown stripes, the median stripe broadly split by a plumbeous line that ends before the suture; lateral stripes crossing the suture and occupying the centers of the scutal lobes; scutellum sparsely pruinose, the margin fringed with setæ; postnotum black, glabrous. Pleura black, sparsely gray pruinose. Halteres short, brown, the knobs dark brown. Legs with the coxæ and trochanters black, sparsely gray pruinose; femora fulvous yellow, the tips broadly blackened, this occupying approximately the distal fifth; remainder of the legs brownish black. Wings yellow, the stigma dark brown; cells C and Sc more saturated; cord, outer end of cell *1st* M_2, veins R, Rs, Cu and *2nd* A broadly suffused with brown; veins beyond the cord and the wing-apex more narrowly seamed with brown; veins dark brown. Venation: Sc_1 ending beyond the fork of R_{2+3}, Sc_2 almost exactly opposite this fork; Rs about one-half longer than R; R_{2+3} shorter than the deflection of R_{4+5}; r a little before midlength of R_2 and about twice its length from the tip of R_1; cell M_1 lacking; cell *1st* M_2 rectangular, shorter than vein M_{1+2} beyond it, but slightly longer than M_3; basal deflection of Cu_1 at about one-third the length of the cell.

Abdomen black, the lateral margins of tergites two to five rather narrowly but conspicuously buffy fulvous; abdomen rather densely pubescent; sternites brownish black, sparsely gray pubescent; a narrow median, fulvous line on sternites two and three; hypopygium black. Pleurites elongate, conspicuous, much longer than the slender pleural appendages.

Habitat: Japan (Hokkaido). Holotype, ♂, Teshio, July 12, 1916 (T. Isshiki). Type in the collection of the Agricultural Experiment Station, Taihoku.

Eriocera fulvibasis bears a general resemblance to *E. longifurca* Alexander (Honshiu), differing in the coloration of the body and legs.

Rhaphidolabis Osten Sacken.

Rhaphidolabis consors sp. n.

Antennæ with twelve segments; general coloration buffy, the mesonotal praescutum with two broad, submedian brown stripes that are confluent or nearly so; head gray; wings subhyaline, stigma barely indicated; abdomen dark brown.

Female—Length about 4.5 mm.; wing, 6.2 mm.

Rostrum and palpi brown. Antennæ brown, twelve-segmented, the terminal segment longer than the penultimate. Head gray.

Mesonotum pale buff, the praescutum with two broad, submedian brown stripes that are nearly confluent; postnotum sparsely pruinose. Pleura buffy, sparsely gray pruinose. Halteres pale, the knobs dark brown. Legs with the coxæ and trochanters pale; remainder of the legs brown. Wings subhyaline, the stigma barely indicated; veins pale brown. Venation: Sc_1 ending some distance beyond the fork of R_{2+3}; Rs gently arcuated; R_{2+3+4} about as long as the basal deflection of Cu_1; R_2 very faint, lying close to the tip of R_1; cell M_1 present; cell *1st* M_2 open; M_{3+4} before the basal deflection of Cu_1 a little shorter than the latter.

Abdomen dark brown; valves of the ovipositor horn-colored.

Habitat: Japan (Honshiu). Holotype, ♀, Tamagawa, Saitama-Ken, November 13, 1920 (H. Machida).

I am indebted to Dr. Machida for this distinct species of *Rhaphidolabis*.

Tricyphona Zetterstedt.

Tricyphona grandior sp. n.

Size large (wing, ♂, 18 mm.); head and thorax dull gray; wings brownish yellow, the cord seamed with brown; abdomen dark brown, the terminal segments still darker.

Male—Length, 18 mm.; wing, 18 mm.

Rostrum dull gray; palpi dark brown. Antennæ very small, the scape dark brown; basal segments of flagellum brownish yellow, the distal segments darkened; flagellar segments becoming greatly crowded and rapidly decreasing in size to the tip; only nine flagellar segments are present, the terminal segment apparently formed by the fusion of two small segments. Head dull gray; on vertex behind antennæ and between the eyes, a conspicuous black, circular depression.

Pronotum dark gray, the scutellum reddish brown. Mesonotal praescutum dull whitish gray with three clearer gray stripes; remainder of the mesonotum dark, light gray pruinose, the postnotum blackened posteriorly. Pleura dark, light gray pruinose; dorso-pleural membrane light brown. Halteres dull yellow, the tips of the knobs a little darkened. Legs with the coxæ obscure yellow, the bases indistinctly pruinose; trochanters dull yellow; legs comparatively stout and hairy; femora brownish yellow, the tips conspicuously dark brown; tibiæ brown, the tips darker brown; tarsi dark brown. Wings with a strong brownish yellow tinge, cells C and Sc more yellowish; central portion of the disk clearer; a brown tinge in cell R from arculus to beyond the origin of Rs; stigma and a conspicuous seam along the cord dark brown; h and Sc_2 narrowly seamed with brown; veins dark brown. Venation: Sc_2 ending opposite the origin of Rs; Rs angulated and spurred at origin; $r\text{–}m$ connected with Rs about its length before the fork; R_{2+3} a little longer than R_3; R_2 about one-half or less R_1 plus R_2; R_{4+5} about equal to R_3, shorter than its branches; cell *1st* M_2 closed; m a little shorter than the petiole of cell M_1; basal deflection of Cu_1 at fork of M; fusion of M_3 and Cu_1 extensive, longer than the basal deflection of Cu_1 alone.

Abdomen with the first tergite obscure yellow basally, the posterior two-thirds darkened; tergites two to four obscure brownish yellow with a broad, ill-defined median stripe; remaining tergites dark, gray pruinose; sternites similar but segments two to four without median stripe. Male hypopygium with the pleural appendage a shiny, obtuse arm that is densely set with more than a score of blackened spines, directed mesad, the whole structure resembling a mace, the mesal end more pointed; ventral margin of this appendage armed with a dense brush or comb of spinous bristles.

Habitat: Japan (Honshiu). Holotype, ♂, Mt. Hakuba, Province of Shinano, July 20, 1918 (S. Issiki). Type in the collection of the Agricultural Experiment Station, Taihoku.

Nesopeza Alexander.

Nesopeza taiwania sp. n.

General coloration dark brown, the praescutal stripes paler than the ground-color; antennæ of male comparatively short; abdomen dark brown, the hypopygium paler.

Male—Length, 8.5 mm.; wing, 10 mm.

Generally similar to *N. orientalis* (Brunetti), differing as follows:

Antennæ of male much shorter, if bent backward not extending far beyond the base of the abdomen, provided with conspicuous verticillate setæ; in *orientalis* the male antennæ are long, extending at least to the base of the fourth abdominal segment and the antennal verticals are very small. Head shiny dark brown. Mesonotal praescutum dark brown with three paler brown stripes, the median stripe divided by a capillary darker line; scutal lobes dark brown, the median area pale. Mesepisternum shiny dark brown, the remaining pleurites paler. Halteres pale, the knobs dark brown. The legs are broken in the type, but Edwards describes them as having the white apices less extensive. Wings suffused with darker; stigma oval, dark brown; *Rs* less arcuated at origin; R_{2+3} longer than the basal deflection of Cu_1. Abdomen dark brown, the hypopygium brighter.

Habitat: Japan (Taiwan). Holotype, ♂, Ringaurin, Nanto, December 18, 1916 (T. Shiraki). Type in the collection of the Agricultural Experiment Station, Taihoku. An additional male in the collection of the British Museum (Natural History).

Edwards (Ann. Mag. Nat. Hist., ser. 9, vol. 8, p. 106; 1921) records this species from the type-locality. His material was badly damaged and was referred provisionally to *N. orientalis* (Brunetti). A comparison of the type of *N. taiwania* with metatypes of *N. orientalis* kindly sent me by Brunetti shows the two species to be distinct.

Pselliophora Osten Sacken.

Pselliophora vulcan sp. n.

General coloration obscure yellow and dark brown; mesonotal praescutum dark brownish black; posterior tibiæ with a broad white ring; wings dark brown with a conspicuous yellow band before cord; abdomen with the apex broadly blackened.

Male—Length, 16 mm.; wing, 12.8 mm.

Frontal prolongation of the head brown, narrowly yellowish dorsomedially; palpi pale brownish testaceous, the terminal segment dark brown. Antennæ with the scape obscure brownish yellow; flagellum dark brown, the branches brownish black. Head brown, more reddish brown posteriorly.

Pronotum brown, the scutellum obscure yellow. Mesonotal praescutum brownish black, only the lateral margins a little paler; a small, yellow, V-shaped mark immediately cephalad of the suture; remainder of mesonotum dark brown. Pleura dark brown, sparsely variegated with yellow; dorso-pleural membrane yellow; an elongate yellow mark on the lateral sclerites of postnotum and the caudal portion of mesepimeron. Sternites dark brown, the dorsal margin of the mesosternum between the mid- and hind-coxæ yellow. Halteres brown, the base of the stem narrowly yellow. Legs with the coxæ dark brown, the basal margin of the posterior coxæ pale; trochanters dark brown; femora brownish black, only the extreme bases paler; tibiæ black, posterior tibiæ with a broad, yellowish white ring beyond the base, this ring barely indicated on the mid-tibiæ; tarsi black. Wings dark brown; cells *Cu*, *1st A* and *2nd A* more brownish gray; a broad yellow crossband extending almost across the wing before the cord, including cells *C*, *1st* R_1 and the outer ends of cells *R* and *M;* a narrower extension follows along vein Cu_2 in cells Cu_1 and *Cu* to the wing-margin; the proximal half of the stigma lies in this yellow band and is much brighter colored; indistinct paler areas as follows: Cell *C* before *h;* the extreme bases of cells *R*, *M* and *Cu;* an indistinct pale crossband about mid-length of cells *Cu* and *1st A;* wing axil conspicuously dark brown, faintly margined with yellow; an obliterative area before the cord, traversing cell *1st* M_2. Wing-petiole fringed with yellow hairs. Venation: Cell M_1 narrowly sessile; *m-cu* distinct.

Abdomen with the basal tergite brown; second tergite yellow on more than the basal half, the apex brown; tergites three to five obscure yellowish brown, the posterior margins darker; remaining tergites black; sternites one to six yellow, the posterior margins darkened; terminal sternites black. Male hypopygium large, black, the ninth segment long and cylindrical. Ninth tergite large with a very deep V-shaped notch, the lateral lobes terminating in subacute shiny points, the ventro-mesal sides of the lobes microscopically punctured. From the region of the ninth sternite there juts dorsad two conspicuous appendages, an inner, cylindrical dark lobe that is covered with a dense, short, golden pubescence and with long bristles on outer face. What is

presumably the gonapophyse appears as an acute, chitinized spine with the base broad, the proximal face with microscopic, longitudinal, parallel ridges, jutting dorsad from the notch of the ninth sternite, from the base of the notch sending ventrad two connate cylindrical arms. Eighth sternite not projecting.

Habitat: Japan (Honshiu). Holotype, ♂, Island of Oshima, Tokyo-Fu, July 16, 1918 (T. Shiraki). Type in the collection of the Agricultural Experiment Station, Taihoku.

Pselliophora vulcan is related to *P. fumiplena* (Walker) and *P. flavibasis* Edwards, but is very distinct from both.

Tipula Linnæus.

Tipula curvicauda sp. n.

General coloration gray; mesonotal praescutum shiny black, only sparsely pruinescent; wings brownish yellow, stigma oval, dark brown; abdomen yellow with two sublateral brown stripes, the terminal segments entirely brownish black; male hypopygium massive, subglobular; outer pleural appendage larger than the inner, appearing as a strongly curved, cylindrical arm.

Male—Length, 18 mm.; wing, 22 mm.

Frontal prolongation of the head grayish pruinose; palpi and mouthparts brown. Antennæ with the scapal segments light yellow, the flagellum broken. Head dark, heavily gray pruinose.

Pronotum gray, narrowly yellowish medially. Mesonotum black, the praescutum only thinly dusted with gray, especially laterally to leave four narrow blackish stripes; scutum and postnotum more heavily pruinose. Pleura light gray pruinose; dorso-pleural membrane light yellow. Halteres obscure brownish yellow. Legs with the coxæ light gray, the apices yellow; trochanters yellow; remainder of the legs broken. Wings with a strong brownish yellow tinge, the base and cells C and Sc brighter yellow, stigma oval, dark brown; an obliterative area before the stigma, extending from the end of cell R across the base of cell *1st* M_2 into M_4, narrowly interrupted by a brown cloud at r–m and the deflection of R_{4+5}; veins dark brown. Venation: Rs longer than R_{2+3}, but shorter than R_3; R_2 persistent; petiole of cell M_1 shorter than m; cell *1st* M_2 pentagonal; m–cu punctiform, at about one-third the length of cell *1st* M_2.

Abdomen with the basal tergite and proximal half of second tergite yellow; tergites two to five yellow with broad, dark brown, sublateral stripes that gradually obliterate the narrow, pale, median vitta; lateral margins of tergites two to seven broadly pale; caudal margins of tergites five and six more narrowly pale; eighth and ninth segments brownish black. Basal sternites yellow, the terminal segments dark brown. Hypopygium large and conspicuous, subglobular, tilted at an angle to the remainder of the abdomen. Ninth tergite massive, the caudal margin with a very broad U-shaped notch. Outer pleural appendage

very remarkable, a long, powerful arm that is strongly curved before midlength. Eighth sternite unarmed.

Habitat: Japan (Honshiu). Holotype, ♂, Kamikohti, Province of Shinano, July 13, 1918 (S. Issiki). Type in the collection of the Agricultural Experiment Station, Taihoku.

Tipûla microcellula sp. n.

General coloration yellowish brown, sparsely pruinose; antennæ of male elongate; wings subhyaline, stigma brown; cell *1st* M_2 very small, pentagonal; abdomen black, only the basal tergites paler sublaterally.

Male—Length about 9 mm.; wing, 10.5 mm.

Frontal prolongation of the head obscure brownish yellow, darker above; nasus long and slender; palpi yellowish brown, the terminal segments dark brown. Antennæ elongate, if bent backward extending about to the base of the third abdominal segment; scape and base of first flagellar segment obscure yellow; remainder of antenna dark brown, the basal enlargements a little darker. Head obscure yellowish brown, darker posteriorly; a capillary, median, brown vitta.

Mesonotal praescutum yellowish gray with three very indistinct brighter brown stripes, the median stripe split by a capillary gray vitta; remainder of the mesonotum reddish brown, dark gray pruinose. Pleura reddish brown, the mesepimeron more testaceous, the pleura sparsely pruinose. Halteres dark brown, the extreme base of the stem yellow. Legs with the coxæ obscure yellow, narrowly darkened basally; trochanters obscure yellow; femora obscure brownish yellow, the tips darkened; tibiæ similar, the tips narrowly darkened; tarsi black, the base of the metatarsi paler. Wings subhyaline; stigma conspicuous, brown; veins brownish black, very narrowly and indistinctly margined with darker; an obliterative area before the stigma, crossing cell *1st* M_2. Venation: Sc_2 ending about opposite five-sixths the length of the long sector; R_{2+3} a little more than one-half Rs; R_2 straight, both sections in alignment, the basal section only a little shorter than the terminal section; R_{2+3} and R_3 in alignment; cell *1st* M_2 very small, pentagonal, the first and second sections of M_{1+2} long, the second section of M_{3+4} still longer; m and the first section of M_{3+4} short; cells M_1, *2nd* M_2 and M_4 very deep; $m\text{–}cu$ punctiform; cell *2nd A* moderately wide.

Abdomen brownish black, the five basal tergites with a faintly indicated paler sublateral stripe; hypopygium black. Male hypopygium small. Ninth tergite entirely separate from the sternite, the pleurite incompletely cut off from the sternite by a long dorsal and a shorter ventral suture. Ninth tergite black with a very deep U-shaped notch, the base of which is occupied by a slightly lower, shiny shelf; lateral lobes rather narrow, the tips obtuse. Ninth pleurite triangular, the apex produced caudad into a conical lobe; outer pleural appendage cylindrical with elongate bristles. Ninth sternite with a very deep, parallel-sided incision. Eighth sternite unarmed.

Habitat: Japan (Taiwan). Holotype, ♂, Funkiko, altitude about 6,000 feet, April 25, 1917 (T. Shiraki). Type in the collection of the Agricultural Experiment Station, Taihoku.

In its venation, *T. microcellula* resembles the African *T. dolichopezoides* Alexander.

Tipula edwardsella nom. n.

New name for *Tipula flavicosta* Edwards, Ann. Mag. Nat. Hist., ser. 9, vol. 8, pp. 106, 107; 1921; preoccupied by *T. flavicosta* Alexander, Proc. U. S. Nat. Mus., vol. 49, pp. 187, 188; 1915.

Mr. Edwards has suggested that I rename his species which was found to be preoccupied. It is with pleasure that this handsome crane-fly is dedicated to Mr. Edwards in appreciation of his critical studies on the Tipulidæ of Taiwan.

Tipula edwardsella belongs to the *mutila* group, a Palæarctic aggregation that is now known to include the following species: *T. mutila* Wahlgren (N. Europe), *T. flavocostalis* Alexander (Japan, Honshiu to Karafuto), *T. percara* Alexander (China, Kwei-chow) and the present species, which is only known from the highest mountains of Taiwan (altitude 10,000 feet).

Tipulodina Enderlein.

Tipulodina nipponica sp. n.

General coloration brownish plumbeous; femora without a pale subterminal ring; fore tibia with one white ring, posterior tibia with two white rings; metatarsi with more than basal half black; wings yellowish subhyaline with a heavy brown pattern.

Female—Length to base of ovipositor, 25 mm.; wing, 19.5 mm.

Frontal prolongation of the head light gray; nasus and palpi brownish black. Antennæ with first scapal segment light yellow, the tip faintly darkened; second segment brownish yellow; flagellum black. Head silvery gray in front, passing into dull gray on the vertex.

Mesonotal praescutum light brownish gray with three very broad, dark brownish plumbeous stripes, the broad median stripe divided by a capillary, dark brown line; remainder of mesonotum dark brownish plumbeous. Pleura light silvery gray, the dorso-pleural membrane light yellow. Halteres brown. Legs with the coxæ light gray pruinose; trochanters yellow; femora obscure yellow, the tips broadly blackened, narrowest on fore legs, broadest on posterior legs; no pale subterminal ring on femora; tibiæ dark brown, fore tibia with a rather narrow (3.5 mm.) white ring before the subequal black tip; middle legs broken; posterior tibia with two white rings, a narrower ring (3 mm.)

immediately beyond the base, a broader (5 mm.) ring before the narrow (3 mm.) black tips, the intermediate black band being approximately equal in extent to the two white bands combined (8 mm.); metatarsi white with from three-fifths (fore legs) to more than half (hind legs) black; remainder of tarsi white, only the terminal segment a little darkened. Wings yellowish subhyaline, heavily marked with brown; cell *Sc* and the stigma dark brown; a brown seam along the cord, interrupted at the deflection of M_{1+2}; wing-tip in cells R_2, R_3, R_5 and the distal half of M_1 dark brown; a broad brown seam along outer end of vein *M*, basal deflection of M_{3+4}, the basal deflection of Cu_1 and Cu_2, almost filling cell Cu_1; a small, subhyaline droplet in the base of cell Cu_1 and another in the end of cell *M;* cell *Cu* and *1st A*, except the base, clouded with brown; veins issuing from cell *1st* M_2 seamed with brown; veins dark brown. Venation: *Rs* only a little shorter than R_{2+3}; petiole of cell M_1 shorter than *m;* cell *2nd A* very narrow.

Abdominal tergites dark brown, the caudal margins of the segments very narrowly, the lateral margins more broadly, buffy yellow; sternites more uniformly buffy yellow, the terminal segment darkened; ovipositor broken beyond base.

Habitat: Japan (Seikaido). Holotype, ♀, Yabakei, August 6, 1918 (T. Shiraki). Type in the collection of the Agricultural Experiment Station, Taihoku.

Tipulodina brunettiella sp. n.

The specimen determined by Brunetti as *Tipulodina pedata* (Rec. Ind. Mus., vol. 15, pt. 5, p. 272; 1918, description; Fauna Brit. India, Dipt. Nematocera, Pl. 5, fig. 4; 1912, figure) is obviously not this species and represents an undescribed form which is named as above. It is distinguished from all described species of the genus by the black costal cell. Brunetti further characterizes the fly as having only the fore femora with a moderately broad, pale apical ring and the basal half of the fore metatarsi and basal third of the hind metatarsi black. Brunetti has determined this species as being *pedata*, although it lacks the brown blotch near mid-length of cell *M*. Wiedemann's description is very clear on this point and I have no doubt but that the species earlier (Proc. U. S. Nat. Mus., vol. 49, pp. 183–185; 1915) determined as *pedata* by the writer really pertains to the species.

Tipulodina taiwanica sp. n.

Related to *T. magnicornis* Enderlein; posterior femora with a pale subterminal ring; posterior tibiæ with a single white ring, subterminal in position; male hypopygium with the pleural appendages not conspicuously projecting.

Male—Length about 28 mm.; wing, 22 mm.

Frontal prolongation of the head brown, narrowly darker dorso-medially; palpi dark brown. Antennæ much longer than in *T. pedata*, if bent backward extending nearly to the base of the halteres; first scapal segment obscure yellow; remainder of antenna black. Head with the front and anterior part of the vertex light yellow; remainder of the head brown, the median line narrowly darker, the inner margin of the eyes narrowly paler.

Mesonotal praescutum obscure brownish yellow with three brown stripes, the median stripe narrow, the lateral margins fading into a paler brown; lateral stripes broad but ill-defined; remainder of mesonotum brown with a darker capillary brown median line, the lateral margins paler. Pleura pale yellow, the lateral sclerites of the postnotum before the halteres with a brown margin. Halteres dark brown. Legs with the coxæ pale, the posterior coxæ with a large brown basal spot; trochanters yellow; legs broken except one posterior leg; in this the femora have a distinct pale subterminal ring followed by the subequal black apex; tibiæ with only the subterminal white ring, this subequal (3.7 mm.) to the black tips; tarsi broken beyond base. Wings subhyaline; cell *Sc* and the stigma dark brown; a tiny brown cloud at origin of *Rs* and a broad seam along the cord, interrupted on the basal deflection of M_{1+2}; Cu_2 and the deflection of Cu_1 conspicuously seamed with brown; a conspicuous brown seam in the outer end of cell R_2 and the distal half of R_3. Venation: Almost as *T. magnicornis* Enderlein (Sumatra); petiole of cell M_1 shorter than *m;* basal deflection of Cu_1 at about one-fourth the length of the cell.

Abdomen reddish brown, the bases of the tergites narrowly more yellowish. Male hypopygium very different in structure from *T. pedata* or *T. magnicornis;* shiny reddish, short-cylindrical, tilted at an angle to the remainder of the abdomen. Ninth tergite very broad and tumid, the caudal margin with a very shallow emargination that bears two widely separated knobs that are clothed with dense short bristles. Tergite and pleurite fused; pleural appendage not projecting beyond the genital chamber, a complex flattened blade with the posterior margin shiny and heavily blackened; ventral pleural suture long and straight. Ninth sternite tumid, with a profound and very narrow V-shaped median notch. Eighth sternite not conspicuously produced caudad.

Habitat: Japan (Taiwan). Holotype, ♂, Shinchiku, July 1–30, 1918 (J. Sonan and K. Miyake). Type in the collection of the Agricultural Experiment Station, Taihoku.

THE VALUE OF LANDMARKS IN INSECT MORPHOLOGY*

ALEX. D. MACGILLIVRAY,
University of Illinois.

The early students of human and comparative anatomy used a sort of hit and miss method in the identification of structures. Time was required for study and exploration to allow for sufficient advancement so that criteria could be established for determining homologies. With the steady advance of anatomical knowledge the identification and establishment of criteria, landmarks, became an important feature. A dictionary of medical terms like that of Gould defines landmarks as "superficial marks, such as eminences, lines, and depressions, that serve as guides to, or indications of deeper seated parts. The knowledge of landmarks is of the utmost importance, both to the surgeon and to the physician."

If external insect morphology is to become of value to the systematist and the homology of the various sclerites is to become fixed, the student of insect-anatomy must establish some method for the identification and location of such landmarks as will serve for the identification of sclerites. The use of landmarks makes for a continuous advancement, any other method makes for the accretion of facts without marked advancement.

Some of the more striking landmarks of the head-capsule that might be cited are the following: The epicranial suture, the precoila, the postcoila, the paracoila, the pretentorina, the metatentorina, the corpotentorium, and the odontoidea.

The inverted Y-shaped suture, the epicranial suture, the stem of the Y, the epicranial stem and each of the two sides an epicranial arm, is believed to mark the line of closure of the head-capsule during embryonic development. This suture is more frequently present in immature insects than in adults, but wherever present marks the position of the front and clypeus enclosed between the epicranial arms and the greater part of the

*Contributions from the Entomological Laboratories of the University of Illinois. No. 74.

head, the vertex, divided into two parts by the epicranial stem. The presence of this suture is indicative not only of the exact position of the sclerites named, but of a generalized condition of the head-structures.

The places where the mandibles and maxillæ are articulated are also important landmarks. The portion of the articular surface on the head or body is known as a coila, while the articular part of the appendage working against the coila is known as an artis. The cephalic articulation of each mandible, a precoila, is always located in the lateral angles of the clypeus, a slight projection on each side that is evidently homologous with the clypealiæ found in the clypeus of the larvæ of Corydalis. The presence of the precoilæ in the clypeus always makes a sure method of identifying this sclerite in all insects where the mandibles are distinct, no matter whether the precoiliæ occur on the cephalic or caudal, or on the dorsal or ventral aspects. The condylar swelling on the mandible articulating in the precoila is the preartis. The other coila of each mandible, the postcoila, is always located in the postgena and serves for the identification of this sclerite, since its limiting suture, the occipital suture, is generally wanting. The value of the postcoilæ in identifying the postgenæ is well shown in the Coleoptera where the postcoilæ are always distinct. The articulation of each maxilla, a paracoila, is also always located in a postgena. The condylar paracoilæ differ from the precoilæ and postcoilæ which are always acetabula. A similar condition is found in other coilæ, they may be either acetabula or condyles, which makes the use of these words, because of the variation in their form, impractical to use.

The point on the external surface where each anterior arm of the tentorium, a pretentorium, is invaginated, a pretentorina, can usually be identified as a depression, pit, or thickening. In generalized insects the pretentorinæ are always associated with the precoilæ and the ends of the epicranial arms and are of great value in fixing the identity of these structures. Where the epicranial stem and the precoilæ are wanting or cannot be identified as in most insects with sucking mouth-parts, the pretentorinæ serve as important landmarks in identifying the epicranial arms along which they may migrate until distant from the clypeus. This migration is so marked in many Diptera and

Hymenoptera that the pretentorinæ have been identified as the supratentorinæ. The relation of the pretentorinæ to the so-called fronto-genal sutures of the orthopterists is direct evidence that they are not distinct sutures, but only the modified ends of the epicranial arms. The presence of pretentorinæ in such moths as the sphingids offers conclusive evidence as to the true homology of the mandibles and pilifers.

The places where the antennæ are articulated to the head-capsule would seem to offer excellent landmarks for the identification of sclerites. The condition and arrangement of the sclerites on the cephalic and caudal aspects of the head, their relation to the occipital foramen, and the position of the occipital foramen show conclusively that such a condition as is found in the Orthoptera with the mouth directed ventrad is more primitive than such a condition as is found in the Plecoptera and Coleoptera, where the mouth is directed cephalad. It is possible to arrange a series of heads showing the development of the plecopterous and coleopterous type from the orthopterous type. The position of the mouth is directly correlated with the method of feeding and the type of mandibular development of the insect. The Coleoptera were undoubtedly derived from insects with the mouth directed ventrad or of the hypognathous type, but all the generalized existing species of Coleoptera have a prognathous type of head or one with the mouth directed cephalad. Several groups of beetles have a hypognathous type of head, but this is an acquired condition as is easily proven by a study of the position of the occipital foramen and the adjacent sclerites, in other words the head is simply bowed at middle. The use of the landmarks named and the metatentorina and gula prove this. In the Coleoptera with the prognathous type of head the antennæ are located in front of the compound eyes while in the hypognathous type of head the antennæ are articulated near together on the middle of the cephalic aspect. A series of heads will show all sorts of positions between those named. A similar migration can be shown in the insects of other orders, all of which goes to show that the articulations of the antennæ are apparently unstable in position and change their location with the change in the shape of the head and the direction of the mouth. The antennæ are usually articulated to the vertex,

but may be articulated to the front. They are not only not fixed in position, but are not definite in their migrations and are consequently not of value, except in very special cases, as landmarks in determining the identity of sclerites.

The corpotentorium, which is formed from a fusion of the metatentoria, is always of value in identifying the position of the postgenæ. It is also an important landmark for indicating the relation of the sclerites that surround the occipital foramen.

The neck or cervix usually contains sclerites on each side, the cervepisternum and cervepimeron, the former of which always articulates against the head. This point of articulation is generally a tooth-like projection on the walls of the head limiting each side of the occipital foramen. It projects into the foramen and each is known as an odontoidea, which serves not only as a landmark of the points of articulation between the head and thorax, but as marking the limits of the occiput and postgenæ. The occipital suture is usually obsolete and the portion of the head-capsule surrounding the occipital foramen dorsad of a line drawn through the odontoideæ is considered as the occiput and the portion ventrad as the postgenæ. Both the occiput and postgenæ are continuous with and indistinguishable from the vertex, of which the genæ, not a distinct sclerite, is a part. While the limits of the postgenæ are not definite, yet by the use of the odontoideæ, the postcoilæ, the paracoilæ, and the corpotentorium much can be determined as to their limits.

The metatentorinæ, structures rarely indicated or mentioned in morphological studies, are of primary importance in identifying structures of the caudal or ventral aspect of the head, depending upon whether it is of the prognathous or hypognathous type. They mark the places where the metatentoria are invaginated, are usually distinct pits, and are always located in the postgenæ near to the lateral ends of the corpotentorium, but always on the outside of the body. They are consequently located near the occipital foramen and the paracoilæ. The metatentorinæ are of primary importance as landmarks in maping out the gula, a structure that is found only in the order Coleoptera, where it can be seen in its primitive condition, in the order Neuroptera where it reaches its maximum development and is prominent in both larvæ and

adults, and in the order Trichoptera where its reduction and specialization in many species is striking. All sorts of head structures have been described as a gula, as a part of the submentum, a part of the ligula, a part of the postgenæ where they have migrated mesad below the occipital foramen and fused, and other structures. The use of metatentorinæ as landmarks for marking off the gula shows conclusively that a gula is present only in the orders named and that the modification of neck structures has had absolutely nothing to do with its origin. The Mecoptera, which are generally placed next to the Neuroptera, do not have a gula and should be associated instead with the Hymenoptera with which they are related. The three orders with a gula are a homogenous group and it should be easy to decide whether the Micropterygidæ belong with the Trichoptera or not by the presence or absence of a gula. If a gula is present the conformation of the head will be very different from those species of Lepidoptera lacking it. The frenate Lepidoptera and the Hepialidæ do not have a gula, although a bar of the labium has been incorrectly identified as such, but this bar bears the labial palpi. The gula is a valuable landmark in the case of trichopterous larvæ in showing specialization. It shows that interpretation of the structures of the head in the larvæ of this order as usually adopted are questionable, that the reverse of the usual interpretation must be adopted, for the campodeiform larvæ are the specialized larvæ and not the generalized as the name would suggest.

The limits of the segments, their cephalic and caudal boundaries, are indicated by the membrane between them, the coriæ, that cephalad of the prothorax, the procoria, that cephalad of the mesothorax, the mesocoria, that cephalad of the metathorax, the metacoria, and that cephalad of the first abdominal segment, the unacoria. These coriæ if reduced to sutures are known as the prosuture, mesosuture, metasuture, or unasuture. On each lateral aspect the metacoria is frequently a suture and is known as the interpleural suture. The mesocoria and metacoria usually contain a pair of spiracles, at least in the adult. Each spiracle is surrounded by chitinized plates, a peritreme. The peritremes and imaginary modifications of the cephalic portion of the sternannum of these segments have been designated as the intersegmental sclerites and homologized

with the cervical sclerites with which they are not homologous in position, form, structure, or function. The peritremes are useful in marking the position of their respective coriæ and the coriæ are invaluable in marking the extent of the segments.

The following landmarks are not only available but useful in identifying structures in the thorax and abdomen. The furcinæ, the depressions marking where the furcæ, parts of the entosternum, are invaginated, are important landmarks, since they are always located between the sternannum and sternellum. The other subdivisions of the sternum reported by authors are of very infrequent occurrence and are never demarcated by landmarks other than indefinite furrows of secondary origin. The furcellina and the arm invaginated from it, the furcella, is always attached to the sternellum and when present, even if the sternellum is membranous, marks its situation. The position of the sternellum is also indicated in some insects by its articulation with a coxa, the sternacoila and the sternartis. The trochantins, although usually greatly reduced in size, are generally present, articulated to a coxa by a trocoila, and associated with the sternannum and coxacoila. The flexible membrane surrounding the proximal end of the leg, the coxa, is known as the coxacoria and is of great value in determining the extent of the coxal segment and the sclerites associated with the coxacoria.

The two structures most useful in determining the dorsal and ventral extent of the mesopleura and metapleura are the coxacoilæ and pleuraliferæ. These structures are located, one, the coxacoila, at the ventral end of the pleural suture, the suture which separates the two primary sclerites of each pleuron, an episternum and an epimeron. The coxacoila is where the primary articulation of each leg, a coxartis, is made with the thorax. The pleuralifera is the primary place of articulation of the wing-sclerites, the pteraliæ, with the pleuron. The pleurademinæ, one of which is always located in the ventral portion of the pleural suture and marks the place of invagination of the pleuradema, a part of the entopleuron. The pleurodema always supports the coxacoila and its position in the pleural suture makes it a landmark for both these structures. In the prothorax the large size of the pronotum and the absence of wings and the small size of the pleural

sclerites makes the procoxacoila of great value in identifying the position of the proepisternum and the proepimeron.

The notum always consists of four sclerites, praescutum, scutem, scutellum, and postscutellum, as was shown by Audouin nearly a century ago. A careful study of the structure of the mesonotum and metanotum will show that these sclerites are always present in adult insects and that there is absolutely no foundation for the conclusion of Snodgrass that this area consists of two sclerites, a notum and postnotum, and that in the Orthoptera the postscutellum is not homologous with the same structure of other orders. The limits of the notal sclerites are marked by many easily identified landmarks and four of these are present and can be identified in wingless insects. To identify the limits of these sclerites, generalized insects should be studied and not those with a greatly modified notal area, modifications due to the specialization of the organs of flight, the wings.

The praescutum is the cephalic sclerite and its caudal limit is a transversely invaginated lamella, the prephragma, which becomes so large in specialized insects that the entire praescutum is invaginated into the phragma and the praescutum can not be identified as in all Hymenoptera. There is a second phragma, the paraphragma, usually present and so far as I have been able to discover not previously described. The paraphragma is a transversely invaginated lamella that is horizontal in position and held near the ental surface of the scutum. This phragma is invaginated between the scutum and the scutellum and marks the caudal limit of the scutum. The caudal extent of the scutellum is marked by the spiralis, the spring-like or trachea-like vein always attached along the caudal margin of the scutellum and extending onto the wing of each side to the axillary incision. The postphragma is rarely present and never of large size and is invaginated along the caudal margin of the postscutellum. The very large phragma of such specialized insects as the Lepidoptera, Diptera, and other orders is not a postphragma, but the prephragma of the metathorax. Generalized insects show a distinct prephragma in both mesothorax and metathorax and never a postphragma in the mesothorax so that the so-called postphragma in specialized insects represents an invagination of the metacoria, metapraescutum, and a part of the metascutum with the metaprephragma.

Other definite criteria for the identification of the four notal sclerites is found in the universal position of the alariæ, the places on each lateral margin of the notum where the wing-sclerites, the pteraliæ, articulate. These alariæ can be identified as follows: The cephalariæ on the praescutum, the medalariæ and caudalariæ, always characteristic in form, on the scutum, and the scutalariæ on the scutellum. The value of these points of articulation as landmarks are further enhanced by the characteristic coria located between them, the cephacoria, the medacoria, and the caudacoria. While not a part of this discussion, it may be of interest to note that the scutellum and postscutellum are not only distinct in generalized insects, but three distinct areas or regions can be identified in the former and four to six in the latter.

One of the most important factors to be decided with regard to the abdomen is always the identity and extent of the different segments. The abdominal segments, like the thoracic segments, are separated by coria, the segmacoria. In some of the caudal segments the coriæ are reduced to sutures. Each segment is divided into two parts, a tergum and a sternum united by a coria, the pleuracoria, on each side. The coriæ are the best landmarks in most cases. The most useful single character in identifying abdominal segments is the knowledge that each of the first eight segments bears a pair of spiracles, so that, when there are eight pairs present, one knows instinctively the homology of the last segment bearing a pair of spiracles is the eighth. Nelson has shown the presence of eleven neuromeres and eleven segments in the embryo, but his observations on the closure of the embryo and the formation of the tergum would suggest the absence of a telson so that it would not be possible to consider the abdomen as consisting of either eleven segments and a telson or twelve segments and a telson, but eleven segments without a telson. The cerci are the appendages of the eleventh segment and, when present, will serve to identify this segment. The two remaining segments must be identified from the articulation of the ovipositor or from the position of the parts of the clasping organs, which is not readily done.

ENTOMOLOGICAL SOCIETY OF AMERICA

Proceedings of the Boston Meeting, 1923

OPENING SESSION.

TUESDAY, DECEMBER 26th.

The Society was called to order at 1:50 P. M. by Doctor J. M. Aldrich. In the absence of the President and both Vice-Preisdents, Dr. Nathan Banks was elected Chairman *pro tem.* Professor R. A. Cooley arrived a little later and presided during the remainder of the session. The attendance ranged from seventy-five to eighty. The following papers were read:

Notes on the Life History of *Clastoptera obtusa* and *Lepyronia quadrangularis.* PHILIP GARMAN, Connecticut Agricultural Experiment Station.

A New Type of Insect Metamorphosis Found in Termites. ALFRED EMERSON, University of Pittsburgh.

The Canadian Life Zone. J. M. ALDRICH, United States National Museum.

The Distribution and Forms of *Lygaeus kalmii* Stal, with remarks on Insect Zoogeography. H. M. PARSHLEY, Smith College.

The Malpighian Vessels of the Chrysomelidæ. WILLIAM COLCORD WOODS, Wesleyan University.

The Occurrence of *Muscina pascuorum* in America. CHARLES W. JOHNSON, Boston Society of Natural History.

The Male Genitalia and the Classification of the Genus *Sphaerophoria* (Diptera). C. L. METCALF, University of Illinois.

The following Committees were appointed:

To serve as substitutes for absent members on the Executive Committee: E. D. BALL, C. W. JOHNSON, C. H. KENNEDY, W. P. FLINT.

Resolutions Committee: G. C. CRAMPTON, ALVA PETERSON, GRACE H. GRISWOLD.

Auditing Committee: H. M. PARSHLEY, D. M. DELONG, P. R. LOWRY.

Nominating Committee: C. T. BRUES, J. S. HINE, EDITH M. PATCH.

Adjournment.

SECOND SESSION.

WEDNESDAY, DECEMBER 27th.

The Society was called to order at 10:00 A. M. by the President, Arthur Gibson. The report of the Executive Committee was made as follows:

REPORT OF THE EXECUTIVE COMMITTEE.

The following business has been transacted by the Executive Committee since the Toronto Meeting and is here reported for record.

An invitation was received to hold a summer meeting of the Society at Salt Lake City in connection with the summer meeting of the American Association for the Advancement of Science in June last. The opinions of the members of the Executive Committee regarding the advisability of such meeting were varied and there did not appear to be sufficient interest among the members in such a meeting to justify attempting it.

The resignation last year of Dr. J. M. Aldrich as Councilor in the American Association for the Advancement of Science left a vacancy which had not been filled until the present year. Article 4, Section 8 of our Constitution provides that in case of the death or resignation of either or both Councilors, the vacancy shall be filled by the Executive Committee. The mail ballot of the Executive Committee during the past summer resulted in the designation of the Secretary to represent the Society at this meeting in place of the past President.

On July 27th, the Executive Committee extended an invitation to Dr. W. M. Wheeler, Dean of Bussey Institution, to give the annual public address of the Society at the Boston meeting. This invitation was accepted.

The Executive Committee has extended much more important help to the Secretary in the arrangements for the Symposium for the present meeting. Many invitations were extended that were not accepted for various reasons, but the response on the whole has been very encouraging.

On March 1st, the Executive Committee, by mail ballot, elected the following to membership:

George C. Wheeler
Maurice Crowther Hall
William Victor Reid
Henry Dietrich
Cho Teranishi
Andrew Fleming
Charles Howard Batchelder
J. B. Lackey

On April 10th the Executive Committee, by mail ballot, elected the following to membership:

Joseph Banghart
Naoto Ishimori
Dr. Francis Metcalf Root

On July 1st the following members were elected by mail ballot:

Clarence H. Brannon
Simon Marcovitch
Alfred Lutken

The Executive Committee met December 26, 1922, at 6:30 P. M., in the Brunswick Hotel, with the following members present: R. A. Cooley, *Chairman;* Herbert Osborn, J. M. Aldrich, O. A. Johannsen, C. W. Johnson, E. D. Ball, W. P. Flint, C. L. Metcalf.

The following were elected to membership:

Alfred Reginald Allen, Jr.
George F. Arnold
Howard Baker
Hastings Newcomb Bartley
James Allen Beal
Arthur I. Bourne
Fred William Boyd
Miss Hazel Elizabeth Branch
Jacob W. Bulger
Eli Kimmie Bynum
Walter Carter
Joseph Conrad Chamberlin
Edgar W. Davis
Clifford Ten Eyck Dodds
Kathleen Clare Doering
Senekerim M. Dohanian
Charles Felix Doucette
Philip Berry Dowden
Carl J. Drake
George Edward Emery
Dr. Teiso Esaki
George A. Filinger
Frank Chittenden Fletcher
Roger Boynton Friend
William Gilbert Garlick
Dr. John Geo. Gehring
Bertram Irving Gerry
Alexander A. Granovoky
Arthur Lee Hamner
Robert John Harington
Edwin A. Hartley
Frank Montgomery Hull
Paul Knight
Dr. Elmer F. Learned
Charles P. Lounsbury
Wm. Middleton
Walter Markley Morris
Basil Elwood Montgomery
Willis Bernard Noble
John Cleary Pearson
Donald T. Ries
Hervey E. Roberts
Mauro G. Rodriguez
Howard Jemney Sampson
Carlton Hill Schaffer
Wendell Folsom Sellers
Harold Henry Shepard
Loren Bartlett Smith
Thomas Elliott Snyder
Anthony Spuler
Geo. Milton Sterritt
Homer S. Swingle
Leland Hart Taylor
Clarence Percy Thornton
Harrison Morton Tietz
Arlo McCrillis Vance
Claude Wakeland
Herbert H. Walkden
F. E. Whitehead
Harlan Noyes Worthley

Total New Members elected during 1922, 74.

E. D. Ball moved that the newly elected President appoint a Committee of three of the Executive Committee, to canvass the membership of the Society with a view of election to fellowship. Motion carried.

J. M. Aldrich moved that the Managing Editor of the Annals be requested to publish a complete revised list of the fellows and members in the March number of the Annals. Motion carried.

On motion the Executive Committee recommended to the Society that the annual dues be raised from $2.00 to $3.00, effective January 1, 1924. It was further recommended that the subscription price of the Annals to non-members be $4.00 a year, and that the Managing Editor be authorized to pay a 10% commission to subscription agencies.

Nathan Banks and A. D. MacGillivray were appointed to succeed themselves as members of the Thomas Say Foundation, their terms to expire December 30, 1924. The resignation of E. D. Ball as Treasurer of the Thomas Say Foundation was accepted and J. J. Davis was appointed as Treasurer.

Acting upon the recommendations of the Society at the Toronto meeting, the $50.00 loaned to the Thomas Say Foundation at the time of its organization was made a grant.

R. A. Cooley, R. W. Harned and G. C. Crampton were elected to succeed S. A. Forbes, A. D. Hopkins and A. L. Lovett on the Editorial Board.

The Executive Committee recommended that the Society approve the constitution for the Union of American Biological Societies as published in Science for September 29, 1922; that the Society meet the expenses of our representatives in attending such meetings as may be called in Washington during the coming year; and nominated as representatives in the Council of this Union for the year 1923, A. N. Caudell and A. G. Boving.

The following resignations as members were presented and by action of the Executive Committee these memberships are hereby terminated:

E. D. Quirsfeld	J. W. Green
John E. Dudley	James K. Thibault
Wesley O. Hollister	Max R. Zappe
Everett E. Wehr	R. L. Lobdell

Total, 8.

Last year the Secretary asked the privilege of retaining on the rolls the names of eleven persons who were in arrears for more than two years, and by strict ruling should have been dropped from membership. A personal letter was addressed to each to determine, if possible, whether he really wished to sever his connection with the Society. Of these eleven persons, two have paid up for the intervening years the sum of $22.00. The remaining nine, together with nine others who have passed beyond good standing in the meantime, were by action of the Executive Committee dropped from membership. Total, 18.

One death has come to the notice of the Secretary during the current year, that of Joseph Daniel Mitchell.

Total loss of membership, 27.

Membership reported 1921 (See Annals, XV, p. 104)	606
Loss during 1922	27
Balance	579
New Members elected during 1922	74
Total present membership	653

The present membership is very encouraging. All of the uncertain memberships which had been held for several years following the war have now been cleared up and the total reported above is a genuine active membership. It is the largest in the history of the Society, the largest previously reported being in 1916, with 611 members, the second largest in 1917 and 1921, with 606. It is interesting to notice the growth since 1911, when our membership was 391.

On December 11th, when the Secretary ceased recording payments of annual dues, the Society was in the following condition with respect to payment of dues. In this connection, it may be noted that the above date is somewhat earlier than that used for the corresponding report last year. A number of payments have been made in the interim, but are not as yet recorded.

	This year	Last year
Members and Fellows paid 3 years in advance	9	1
Members and Fellows paid 2 years in advance	2	3
Members and Fellows paid 1 year in advance	179	222
Members and Fellows paid for year just ending	324	235
Members and Fellows 1 year in arrears	23	52
Members and Fellows 2 years in arrears	22	18
Members and Fellows 3 years in arrears	0	11
Life Members	15	13
Honorary Fellows	4	4
New Members	74	47
Totals	653	606

Respectfully submitted,

C. L. Metcalf, *Secretary-Treasurer.*

The Report of the Executive Committee was received.

The report of the Treasurer was presented as follows:

REPORT OF THE TREASURER.

(December 21, 1922)

Current Funds.

Receipts.

Balance, Dec. 24, 1921 (See Annals, Vol. XV, p. 107)	$1,167.12
From Annual Dues of Members	1,069.10
From Managing Editor of the Annals	499.47
From Life Memberships (Moffatt & Mann)	100.00
From Interest	31.10
From sale of bond (Victory Loan called)	50.00
Checks refused by banks (to balance)	12.00
Total Receipts	$2,928.79

Expenditures.

Annals for March, 1921, including reprints	$248.00
Annals for June, 1921, including reprints	366.50
Annals for Sept., 1921, including reprints	311.25
Annals for Dec., 1921, including reprints	425.95
Annals for March, 1922, including reprints	355.00
Postage, envelopes, stationery for Annals	36.30
Engraving for Annals (part paid by Treasurer)	56.21
Stamps and Stamped paper, Secretary's office	31.91
Clerical and Stenographic Assistance, Secretary's office	86.66
Printing and stationery, Secretary's office	56.30
Office supplies, Secretary's office	19.00
Express	.78
Telegrams	1.82
Safety Deposit Box	1.80
Lost by exchange	.68
Checks refused by bank (to balance)	12.00

To Editor Annals for volume for F. Silvestri	4.00
Credit Secretary on account of error in balance for last year as found by Auditing Committee	1.50
Total Expenditures	$2,015.70
Balance, Cash on hand, First National Bank, Champaign, Ill., Dec. 21, 1922	913.09
	$2,928.79

Of this amount $200 belongs to our Permanent Fund ($50 from Life Membership last year, $100 from Life Memberships this year and $50 sale of a bond) leaving an amount available to meet our obligations...$713.09

LIABILITIES.

The Society owes the publishers of the Annals for the June, September and December, 1922, issues, being in this respect one issue ahead of our status last year and two issues ahead of our status the year before.

The only other outstanding bill the Secretary knows of is that for the Annual programs which is approximately $25.00.

CONDITION OF PERMANENT FUNDS.

On hand, latest report (Annals, Vol. XV, p. 108)	$841.31
Appreciation on nine War Savings Stamps	2.69
Two life memberships, Mrs. Moffatt and Wm. Mann	100.00
Total	$944.00

SECURITIES HELD.

Liberty Bonds estimated at their face value.

First Liberty Loan Bond Bo. B00911757	$ 50	
Second Liberty Loan Bond No. B02787752	50	
Third Liberty Loan Bond No. 5876279	50	
Third Liberty Loan Bond No. 5876278	50	
Third Liberty Loan Bond No. 5876280	50	
Third Liberty Loan Bond No. 4203250	100	
Third Liberty Loan Bond No. 4203251	100	
Fourth Liberty Loan Bond No. H05321828	100	
Fourth Liberty Loan Bond No. C04921513	50	
Fourth Liberty Loan Bond No. D04921514	50	
Fourth Liberty Loan Bond No. E04921515	50	
(The last named converted from No. 14, 145, 891).		
Nine War Savings Stamps	45	
Total Face Value of Securities		$745.00
Balance carried in current account		199.00

Victory Liberty Loan Bond No. A1,562,358 has been called and cashed for face value, $50.00.

Respectfully submitted,

C. L. Metcalf, *Treasurer.*

On motion, the report of the Treasurer was accepted and the financial matters involved referred to the Auditing Committee.

The next item of business was the Report of the Managing Editor of the Annals.

REPORT OF MANAGING EDITOR.

I am pleased to report that the numbers of the ANNALS issued for the year will be covered by income, and while not as large as might be desired, we believe it will be a creditable volume. The receipts of the office have totalled $745.58; the classified summary of receipts and expenditures being as follows:

Receipts.

Subscription account	$349.51	
Sale of back volumes	85.22	
Reprints and contributions for engraving	310.85	
Total		$745.58

Expenditures.

Stenographic, clerical help and labor	$ 37.26	
Postage, postal deposit, exchange, etc.	61.76	
Engraving	147.09	
Balance to Treasurer	499.47	
Total		$745.58

Our library subscription list has been maintained, and foreign subscriptions somewhat increased. The income from back volumes, while not equal to that of last year, will be somewhat augmented by sets recently ordered but not yet paid for. We may, therefore, plan, I think, for a somewhat enlarged volume for the coming year. As in recent years we have had desirable papers that could not be published promptly for lack of funds, and any increase of income can be readily used in the publication of creditable papers.

I am much indebted to Dr. C. H. Kennedy for his efficient assistance.

Respectfully submitted,

HERBERT OSBORN.

On motion, this report was accepted and referred to the Auditing Committee.

The next report was that of the Treasurer of the Thomas Say Foundation.

REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

(For the Year 1922.)

Receipts.

Balance on hand January 1, 1922	$285.73
Seven subscribers at $3.00	21.00
Interest on $200.00 (to Sept. 15)	8.50
Total Receipts, 1922	$315.23

Expenditures.

Postage on seven copies	$ 1.01
Total expenditures, 1922	$ 1.01
Cash on hand to balance	314.32
Total	$315.23
Balance on hand, January 1st, 1923	$314.32

There are outstanding obligations to the original subscribers of $260.00, leaving a net balance of $54.32 to the credit of Volume I if the original grant of the Society of $50.00 is neglected, or $4.32 if it is considered.

E. D. BALL, *Treasurer*.

On motion this report was accepted and referred to the Auditing Committee.

The following report was then presented and accepted:

REPORT OF COMMITTEE ON RESOLUTIONS.

Be It Resolved, that the Entomological Society of America extend its sincere thanks to the Massachusetts Institute of Technology, for its hospitality and for the splendid facilities furnished, which have made these meetings a success.

ALVA PETERSON,
G. C. CRAMPTON,
GRACE H. GRISWOLD.

The Report of the Auditing Committee was not presented to the Society at this session, nor at the later sessions, but by vote of the Society the receipt of this report was delegated to the Executive Committee, with power to act. (Secretary's Note.—Each member of the Executive Committee has approved in writing the report of the Auditing Committee, which is as follows:)

REPORT OF AUDITING COMMITTEE.

Your Auditing Committee has examined the accounts of the Entomological Society of America, the Managing Editor of the Annals, and the Thomas Say Foundation, and finds them to be correct.

(Signed) H. M. PARSHLEY, *Chairman*,
D. M. DELONG,
P. R. LOWRY.

The Report of the Nominating Committee was presented as follows:

For President—T. D. A. COCKERELL.
For First Vice-President—WM. S. MARSHALL.
For Second Vice-President—F. E. LUTZ.
For Members of the Executive Committee—ARTHUR GIBSON, W. A. RILEY, R. A. COOLEY, C. W. JOHNSON, E. P. FELT, A. L. MELANDER.
For Secretary-Treasurer—C. L. METCALF.

On motion, the Secretary was instructed to cast the ballot for the unanimous election of these officers. This being done, the officers were declared duly elected.

The following reports of special committees were read and received:

REPORT OF THE DELEGATE TO THE INTER-SOCIETY CONFERENCE

Washington, D. C., April 21.

At the Toronto meeting, the Society delegated its Secretary and President to represent it at an Inter-society Conference, created to study the feasibility of

a federation of the various biological societies in America, and to develop plans for such a federation.

The Division of Biology of the National Research Council requested that only one representative from each society be sent to this conference. It was agreed that the Secretary should act as the official representative of the Society at this meeting, while the President was good enough to be present on his own responsibility.

This conference, after some debate, affirmed its belief in the desirability and feasibility of a federation of biological societies and adopted a general plan in accordance with which such a federation might be established. Outlines of this plan as it has been further developed and a proposed constitution embodying the details of the plan which was worked out by a special committee meeting in Woods Hole, Massachusetts, August 4 and 5, 1922, have been published from time to time in *Science*, and a rather full report was sent to each member of this Society with the announcement of the present meeting.

(Signed) C. L. Metcalf,
Arthur Gibson.

REPORT OF THE SPECIAL COMMITTEE

Appointed to extend to prominent entomologists of Central and South America an invitation to become members of the Entomological Society of America.

At the Toronto meeting the Society appointed a special committee, consisting of the President, the Secretary, and Dr. J. Chester Bradley, to invite officially the entomologists of Central and South America to join the Entomological Society of America.

As a result of the work of this committee, about twenty-five personal letters of invitation have been written to a list of prominent entomologists whose names and addresses were supplied by Dr. Bradley, and most of these have been accompanied by a personal letter from Dr. Bradley.

Up to the present time, no replies have been received from these invitations, but it is hoped that the work may bear fruit that can be reported upon at the next annual meeting.

(Signed) Arthur Gibson,
C. L. Metcalf,
J. Chester Bradley.

On motion the Society voted to enter into the Union of Biological Societies, and to adopt the recommendations of the Executive Committee, as recorded above, with respect to this matter.

On motion the Society voted to raise the annual dues of members from \$2.00 to \$3.00, and the subscription price to non-members from \$3.00 to \$4.00, in accordance with the recommendation of the Executive Committee, recorded above. It was moved that the life membership fee be raised from \$50.00 to \$75.00, but after some debate the motion was defeated.

The following amendments to the Constitution, which were proposed last year, were passed by vote of the Society:

Article V, Section 4, The Election of Honorary Fellows, which read as follows:

All nominations for Honorary Fellows shall be made in the manner prescribed for the nomination of Fellows, (that is, signed by three or more Fellows and accompanied by full information concerning the nominee) the nominations being presented to the Executive Committee, who shall mail ballots to Fellows. Election shall be by mail ballot of the Fellows of the Society, a two-thirds vote of all Fellows being required for election.

is thereby amended to read as follows:

Honorary Fellows may be nominated by unanimous vote of the members of the Executive Committee present at an annual meeting. The nominee shall be voted on by the members by ballot, and must receive four-fifths of all ballots cast to be elected. Not more than one Honorary Fellow may be elected in three successive annual meetings.

Article VI, Meetings, which read as follows:

An annual meeting shall be held in conjunction with the annual meeting of the American Association for the Advancement of Science, and at such time and place as the officers may elect.

is thereby amended to read as follows:

An annual meeting shall be held in affiliation with the American Association for the Advancement of Science, or at such time and place as the Executive Committee may select.

The following amendment to the Constitution was proposed, and will be acted upon at the next annual meeting.

Article IV, Section 3. *Councilors to the American Association.*—The President and the preceding past President shall represent the Society upon the Council of the American Association for the Advancement of Science. In case of the death or resignation of either or both Councilors, the vacancy shall be filled by the Executive Committee.

It is proposed to amend this Section to read as follows:

Two representatives in the Council of the American Association for the Advancement of Science shall be elected by ballot at the annual meeting for the term of one year, and shall be eligible for re-election. In case of the death, resignation, absence, or inability to serve, of either or both Councilors, the vacancy shall be filled by the Executive Committee.

Adjournment.

THIRD SESSION.

Wednesday, December 27th.

The Society was called to order at 1:30 P. M. by the President. The following program was presented:

SYMPOSIUM

"ADAPTATIONS OF INSECTS TO SPECIAL ENVIRONMENTS"

PART I.

(Each paper to occupy ten minutes and to present the more noteworthy examples of adaptations to the particular environment discussed, the more striking features of the habitat, and something of the course of evolution or development of the adaptations.)

Adaptations to the Aquatic Habitat. NATHAN BANKS, Museum of Comparative Zoology, Harvard University.

Adaptations to the Subterranean Habitat. HERBERT OSBORN, Ohio State University.

Adaptations to the Boring Habit. J. M. SWAINE, Canadian Department of Agriculture.

Adaptations to Cold. ROYAL N. CHAPMAN, University of Minnesota.

Adaptations to the Fertilization of Flowers. F. E. LUTZ, American Museum of Natural History.

Adaptations of Gall Insects. E. P. FELT, State Entomologist of New York.

Adaptations to Social Life. THOS. E. SNYDER, United States Bureau of Entomology.

Adaptations of Ant and Termite Guests. C. T. BRUES, Bussey Institution.

PART II.

(Each paper to occupy not more than three minutes, and to deal with a single species of insect or a single unit of adaptation.)

The Most Remarkable Adaptation I have Observed Among the:

Orthoptera. JAS. A. G. REHN, Philadelphia Academy of Natural Sciences.
Ephemerida. ANN H. MORGAN, Wellesley College.
Odonata. P. P. CALVERT, University of Pennsylvania.
Trichoptera. CORNELIUS BETTEN, New York State College of Agriculture.
Fulgoridae. Z. P. METCALF, North Carolina State College.
Aphididae. A. C. BAKER, United States Bureau of Entomology.
Coccidae. G. F. FERRIS, Stanford University.
Heteroptera. H. M. PARSHLEY, Smith College.
Micro-lepidoptera. ANNETTE F. BRAUN, University of Cincinnati.
Tipulidae. C. P. ALEXANDER, Massachusetts Agricultural College.
Sarcophagidae. J. M. ALDRICH, United States National Museum.
Tachinidae. J. D. TOTHILL, Canadian Department of Agriculture.
Vespidae. J. C. BRADLEY, Cornell University.
Araneida. J. H. EMERTON, Boston.

It was moved and carried that the Editorial Board be requested if possible to assemble the papers of the Symposium, to be published in a single number of the ANNALS.

By ballot vote, the Society selected as the subject of the Symposium for the Cincinnati Meeting in 1923, "Methods of Protection and Defense Among Insects."

Adjournment.

FOURTH SESSION.

WEDNESDAY, DECEMBER 27th.

The Society was called to order at 8:30 P. M. by the President, who introduced the speaker of the evening, Doctor W. M. Wheeler, who delivered a most entertaining and instructive address on "The Physiognomy of Insects." The attendance at this session was about 250.

Following this address the Society adjourned to attend the biologists' smoker in Walker Memorial Hall.

FIFTH SESSION.

FRIDAY, DECEMBER 29th.

The Society was called to order at 10:00 A. M., with the President in the chair. The following papers were presented:

Technique in Studying by Dissection the Internal Anatomy of Small Insects. RALPH H. SMITH, San Francisco.

The Insect Collections of the Boston Society of Natural History. CHARLES W. JOHNSON, Boston Society of Natural History.

Stone Flies of the Genus *Nemoura*. P. W. CLAASSEN, Cornell University.

The Exoskeleton as a Factor Limiting and Determining the Direction of Insect Evolution. CLARENCE H. KENNEDY, Ohio State University.

Wing-venation of the Buprestidae (Coleoptera). HENRY G. GOOD, Cornell University.

Injury to Wood Caused by Oviposition of *Ceresa bubalus* Fabr. F. A. FENTON and J. C. GOODWIN, Iowa State College.

Notes on Insect Polyembryony. R. W. LEIBY, North Carolina Department of Agriculture.

Some Observations on the European *Dichomeris marginellus* Fabr. L. HASEMAN, University of Missouri.

The following exhibits were available for examination during the entire course of the meetings:

An Inexpensive and Efficient Variable Illuminator for use with the Binocular Microscope. C. T. BRUES, Bussey Institution, Harvard University.

Drawings of the Fulgoridae of Eastern North America. Z. P. METCALF, North Carolina State College.

Larval Habits of *Coleophora coenospiennella*. ANNETTE F. BRAUN, University of Cincinnati.

Photographs of Scent-organs in the Genus *Hydroptila* (Trichoptera). MARTIN E. MOSELY, London, England.

SPECIAL NOTICE TO MEMBERS.

The revised membership list of the Entomological Society of America will be published with the June issue. At the request of certain members the Secretary will undertake to include in addition to the correct address a statement of the taxonomic group in which any member is especially interested and whether he is willing to make identifications in such group. Members are therefore urged to make sure that the Secretary has their correct mailing address and also a statement of their special interests, if such statement has not been made on the information blank already sent to the Secretary.

C. L. METCALF, Secretary-Treasurer,
Nat. Hist. Bldg., University of Illinois, Urbana, Ill.

ANNALS

OF

The Entomological Society of America

Volume XVI JUNE, 1923 Number 2

WALKER'S SPECIES OF MEMBRACIDAE FROM UNITED STATES AND CANADA

W. D. FUNKHOUSER,
University of Kentucky.

Francis Walker in his "List of Specimens of Homopterous Insects in the Collection of the British Museum" (Part II, 1851) and in his Supplement to that catalogue (1858) described twenty-nine species of Membracidae from America north of Mexico. Unfortunately, many of his descriptions are so inadequate that although the membracids of this region are now fairly well known, yet a large number of his species have never been certainly recognized and a few have been practically relegated to the limbo of "lost species."

A number of years ago the writer began a critical study of the literature of these species together with careful examination of specimens of the known North American forms as represented in extensive collections in order to determine if possible the species to which Walker's descriptions referred. At the same time an attempt was made to secure accurate figures of Walker's types in the cases of all species which had not been surely recognized. Through the courtesy of Mr. W. L. Distant the services of Mr. Horace Knight, an artist of the British Museum, were secured for this work. Mr. Knight had been making drawings for Mr. Distant for over thirty years, his work was recognized as unusually excellent, and the drawings were to be personally checked by Mr. Distant. Mr. Knight, however, had completed but one study—two views of Walker's "*Thelia collina*"—when his illness brought his work at the

Museum to an end in the summer of 1917. In 1919 the work was resumed by his son, Mr. Edgar S. Knight, who completed studies of six more of the type specimens and then reported that it was impossible for him to go further with the work until Mr. Distant returned to the Museum as there was no other person who was familiar with the arrangement of the collections and who could positively locate the desired specimens for him. At about the same time Mr. Distant wrote that he had been forced to leave London for a rest cure and might not be able to return for some time. The matter of the figures was therefore left in abeyance. Mr. Distant's death last summer has made it necessary to abandon the idea of securing the remaining drawings of type specimens but with the work which has been done in the matter of comparisons and with the figures already received, it is believed that the following list may be offered as representing the correct status of Walker's species. The species are listed in the order in which they were described and the synonymy is indicated.

In interpreting Walker's descriptions it is assumed that his measurements given for the wings in lines refer to the distance between the wing-tips of the spread insects. Also, we are convinced that in the matter of genera Walker generally followed for the Membracidae the classification proposed by Fairmaire (Revue de la tribu des Membracides. Annales de la societe entomologique de France) in 1846.

1. *Enchenopa antonina* Walker = **Campylenchia latipes** Say.

1824. Membracis latipes Say. Narr. Long's Exped. Append. 302.5.
1851. Enchenopa antonina Walk. List Hom. Brit. Mus. 488.32.
1869. E. (Campylenchia) curvata (part) Stal Hem. Fabr. 43.3.
1894. Campylenchia curvata Godg. Cat. Memb. N. A. 464.223.
1916. Campylenchia latipes VanDuz. Check List Hem. 62.1734.

This species must be referred to Stal's genus *Campylenchia* on account of the structure of the pronotal horn and the markings of the pronotum as described. Stal included it in his subgenus *Campylenchia* in 1869 and considered both it and *Membracis latipes* Say as synonyms of *C. curvata*. It was correctly assigned to the genus Campylenchia by Goding in 1894 (Bull. Ill. State Lab. Nat. Hist. VII 3, p. 464) but Goding followed Stal in confusing *C. curvata* and *C. latipes* and making both *C. latipes* and *C. antonina* synonyms of *C. curvata*.

Only two species of the genus *Campylenchia* are known to occur in the United States (the locality given by Walker for

his *E. antonina*). Of these, *C. latipes* Say is by far the more abundant and more widely distributed, the other species, *C. curvata* Fabr., being a small southern form found rarely in the southern part of this country.* Unfortunately the two species were confused for many years and most of the references to *C. curvata* in the literature up to the publication of VanDuzee's Check List in 1916 really referred to *C. latipes*. *C. latipes* shows a wide range of variation in size, in the shape of the pronotal horn, and in coloration, and to this species must be assigned a number of the supposed new species of the earlier writers.

2. *Enchenopa venosa* Walker = **Campylenchia latipes** Say.

1824. Membracis latipes Say Narr. Long's Exped. Append. 302.5.
1851. Enchenopa venosa Walk. List Hom. Brit. Mus. 488.33.
1869. E. (Campylenchia) curvata (part) Stal Hem. Fabr. 43.3.
1894. Campylenchia curvata (part) Godg. Cat. Memb. N. A. 464.223.
1916. Campylenchia latipes VanDuz. Check List Hem. 62.1734.

Walker apparently separated this species from the preceding only on the characters of larger size, slight differences in the branching of the ridges of the horn, and some variation in color. With our present knowledge of the variation commonly found in *C. latipes* these characters can not be considered as specific. The localities given by Walker are the United States and New York. Since *C. latipes* is the only member of the genus known to occur in New York it would appear that *E. venosa* must be assigned to that species.

3. *Enchenopa frigida* Walker = **Campylenchia latipes** Say.

1824. Membracis latipes Say Narr. Long's Exped. Append. 302.5.
1851. Enchenopa frigida Walk. List Hom. Brit. Mus. 490.36.
1858. Walk. List Hom. Brit. Mus. Suppl. 126.
1869. E. (Campylenchia) curvata (part) Stal Hem. Fabr. 43.3.
1894. Campylenchia curvata (part) Godg. Cat. Memb. N. A. 464.223.
1916. Campylenchia latipes VanDuz. Check List Hem. 62.1734.

This species has had the same history as the two preceding. It was placed in the subgenus Campylenchia by Stal as a synonym of *C. curvata* and was so accepted by later writers who followed Stal in considering *C. latipes* a synonym of *C. curvata*. *E. frigida* was described from Nova Scotia and a variety described in the Supplement is recorded from Canada. *C. latipes* is our only northern species of the genus.

* We have a small series from Agricultural College, Mississippi, and have seen specimens from Texas.

E. frigida seems to have been described as a new species chiefly because of a slight tomentose pubescens on the prothorax and a somewhat different shape of the pronotal process. These characters would certainly not be sufficient to distinguish it specifically from *C. latipes.*

4. *Enchenopa bimaculata* Walker = **Campylenchia latipes** Say.

1824. Membracis latipes Say. Narr. Long's Exped. Append. 302.5.
1851. Enchenopa bimacula Walk. List Hom. Brit. Mus. 491.37.
1869. E. (Campylenchia) curvata (part) Stal Hem. Febr. 43.3.
1894. Campylenchia curvata (part) Godg. Cat. Memb. N. A. 464.223.
1916. Campylenchia latipes (part) VanDuz. Check List Hem. 62.1734.

There seems to be no question but that the above synonymy as accepted by recent homopterists is correct. We have examined several thousand specimens of *C. latipes* and find that at least one out of every three of the northern forms (*E. bimacula* is described from Trenton Falls, N. Y.) shows the triangular extension of the vertex on each side where it meets the clypeus decidedly ferruginous or lighter in color than the rest of the head, and the anterior ridge of the horn the same color, thus agreeing with Walker's description and doubtless representing the character which suggested the specific name.

5. *Enchenopa brevis* Walker = **Enchenopa binotata** Say.

1824. Membracis binotata Say Narr. Long's Exped. 301.4.
1851. Enchenopa brevis Walk. List Hom. Brit. Mus. 492.39.
1908. Enchenopa binotata (part) VanDuz. Stud. N. A. Memb. 112.

E. binotata is the only abundant and widely distributed species of the genus in the United States (Walker gives "United States" as the type locality for *E. brevis*) and is the only species of Enchenopa known in this country which has the two characteristic spots on the dorsal ridge. Walker's description of *E. brevis,* however, states that the posterior of these spots is "at the tip." An examination of many hundred specimens of *E. binotata* fails to show an example which agrees with this description as in all cases the posterior spot is some distance from the posterior end of the pronotum. In all other respects his description will fit numerous specimens with attenuated anterior processes.

If our synonymy is correct, Walker must have been either careless in writing his description or he had before him an aberrant example in which the posterior spot reached the end of the process.

6. **Ceresa basalis** Walker.

1851. Ceresa basalis Walk. List Hom. Brit. Mus. 527.12.
1889. Ceresa brevicornis (error) Prov. Pet. Faun. Can. 3.235 (female).
1889. Ceresa semicrema (error) Prov. Pet. Faun. Can. 3.235 (male).
1893. Ceresa melanogaster Osborn. Bull. Nat. Hist. Lab. Iowa State Museum, II:390.
1894. Ceresa turbida Godg. Cat. Mamb. N. A. 406.44.

The dark color, hairy pronotum, dark markings on head, acute black-tipped posterior process, black underparts, and broad black bands on femora, as described by Walker, have been accepted as characters sufficient to distinguish this species. It is common in the type locality (Nova Scotia) and throughout southern Canada and northern United States.

We can not agree with VanDuzee (Check List and Catalogue) in making *Stictocephala semi-brunnea* Buckton (spelled "semibrunneata" for the figure, Pl. 36, Fig. 6) a synonym. Buckton's description is, to be sure, entirely inadequate, and his figure practically worthless from a scientific standpoint, but we believe that both refer to a Stictocephala, as he notes only color differences between *S. semibrunnea* and S. *inermis*, and plainly states that the latter is without suprahumerals.

7. **Ceresa brevis** Walker. (Fig. 1).

1851. Ceresa brevis Walk. List Hom. Brit. Mus. 528.13.
1869. Stal Bid. Memb. Kan. 245.3.
1877. Butler Cist. Ent. II:218.21.
1894. Godg. Cat. Memb. N. A. 403.29.
1908. (error) VanDuz. Stud. N. A. Memb. 40.12, Pl. 1, figs. 35, 36.
1913. Rept. Ent. Soc. Ont. No. 36:135.
1916. (error) VanDuz. Check List Hem. 58.1582.
1917. (error) Gibson and Wells Bull Brook. Ent. Soc. 12.5.111.
1917. (error) VanDuz. Cat. Hem. 525.1582.
1920. Britton Check List Ins. Conn. 53.

This species is close to *C. basalis* Walk. but may be at once distinguished superficially by its larger size, longer horns, and smooth shining pronotum. It has black markings on the under surface similar to *C. basalis* but *C. basalis* is densely hairy while *C. brevis* is entirely without pubescence.

We believe that Gibson and Wells were entirely wrong in their diagnosis of this species. They give as the key characters "suprahumerals short, reduced to a short tubercle" although the original description plainly states that the suprahumerals are "acute, rather long, and slightly curved backwards" and Mr. Knight's figure shows this to be the case.

We believe, also, that VanDuzee is mistaken in his identification (which he gives as doubtful). We think that we have

specimens of the species which he describes in his "Studies of North American Membracidae" and consider them as distinct. Reference to his description and the figures accompanying it will at once reveal decided differences when compared with Walker's description and Knight's drawing.

We have specimens of *C. brevis* ranging from New York to Kentucky. New York is the type locality.

8. *Ceresa apicalis* Walker = **Vanduzea arquata** Say.

1831. Membracis arquata Say. Journ. Acad. Sci. Phila. VI:302.12.
1851. Ceresa apicalis Walk. List Hom. Brit. Mus. 533.33.
1894. Vanduzea apicalis Godg. Cat. Memb. N. A. 441.139.
1916. Vanduzea (?) apicalis VanDuz. Check List Hem. 61.1711.
1917. VanDuz. Cat. Hem. 552.1711.

Goding recognized this species as a *Vanduzea*, and VanDuzee, while questioning the validity of the species, lists it under that genus in his Check List and Catalogue.

Examination of a long series of *V. arquata* Say, probably the most abundant and widely distributed species of the genus in eastern North America, shows that Walker's description will fit perfectly many individuals, particularly females of small size with weak pubescence and distinct markings. It seems unwise, therefore, to consider *apicalis* as distinct.

9. *Aconophora guttifera* Walker = **Platycotis vittata** Fabricius.

1803. Centrotus vittatus Fabr. Syst. Rhynch. 20.23.
1851. Aconophora guttifera Walk. List Hom. Brit. Mus. 539.15.
1869. Platycotis vittata Stal Hem. Fabr. II:37.

This species with its variety *quadrivittata* Say has been much confused because of its great variation, its wide distribution, and the fact that both sexes are found both with and without the porrect horn. The result has been a large number of synonyms.

Walker's description undoubtedly refers to the typical form as he certainly would have noted the four red lines characteristic of the variety had they been present on his type specimen. *P. vittata* was described from "Carolina." It is common in Florida, the type locality of Walker's species.

10. **Entylia concisa** Walker.

1851. Entylia concisa Walk. List Hom. Brit. Mus. 547.6.
1851. Entylia decisa Walk. List Hom. Brit. Mus. 548.7.
1889. Entylia concava (error) Prov. Pet. Faun. Can. III:233.

The genus *Entylia* is still in much confusion due largely to the number of species which have been described, some of which are doubtless invalid, and the hesitancy of systematists to attempt to reduce these species to synonymy because of the apparent lack of natural specific characters and the overlapping of the forms. Matausch in 1910 (Matausch, Ignaz. Entylia Germar and its different forms. Journ. N. Y. Ent. Soc. XVIII: 4. pp. 260–263, and Plate VIII, Dec., 1910) believed not only that *E. sinuata* had been described under twenty-one different names, but suggested that the genus Publilia should also be considered as a synonym. While this extreme view can not be supported, there is no question but that several of the species now usually listed as distinct really represent a single form with its variations. A good many years ago, when the writer had only a few hundred specimens of the genus in his collection, he was quite sure that he could distinguish a number of very distinct species; at the present time, with many thousand specimens of the genus, representing all parts of the United States, available for study, he is far less sure of his determinations.

However, it is believed that at least four species may be recognized in the United States and Canada. These are *E. sinuata* Fabr., *E. bactriana* Germ., E. *concisa* Walk., and *E. carinata* Forst. It is admitted that the characters used in their recognition are largely artificial and superficial, being chiefly those of size, sculpturing, structure of pronotum, and color, all of which are known to vary to a considerable degree within a species, but these species seem to be rather well delimited by an absence of intermediate forms, and in some cases by a more or less definite geographical distribution.

We can not agree with VanDuzee that *E. bactriana* should be made a synonym of *E. carinata*, chiefly for the reason that while we may be fairly sure of the form which Germar described, we can not be equally sure of the insect which Forster had before him, and also because we have Canadian material which answers to Forster's description and which we do not consider identical with *E. bactriana*.

If *E. concisa* is distinct, as we believe, its chief distinguishing characters are the large size, the short head, the high falcate anterior process which leans over the head and extends at a sharp angle far caudad at its dorso-caudal margin, including

with the posterior crest, in Walker's words "three-fourths of a circle." Its range as represented in our collection is limited chiefly to the eastern part of the United States south of the Ohio River. The type locality as given by Walker is St. John's Bluff, E. Florida. We are finding it the dominant form in Kentucky.

11. *Entylia decisa* Walker = **Entylia concisa** Walker.

1851. Entylia concisa Walk. List Hom. Brit. Mus. 547.6.
1851. Entylia decisa Walk. List Hom. Brit. Mus. 548.7.

Apparently described from a dark-colored specimen of the preceding. We have individuals which are entirely black. The type locality for *E. decisa* is the same as that of *E. concisa* and the species seems to have been distinguished by Walker only on the basis of a slight difference in size and a considerable variation in color.

12. *Entylia accisa* Walker = **Entylia bactriana** Germar.

1835. Entylia bactriana Germ. Silb. Rev. Ent. III:248.3.
1851. Entylia accisa Walk. List Hom. Brit. Mus. 548.8.
1851. Entylia indecisa Walk. List Hom. Brit. Mus. 549.10.
1851. Entylia reducta Walk. List Hom. Brit. Mus. 549.11.
1877. Entylia accisa Butler Cist. Ent. II:211.3.
1894. Entylia sinuata (part) Godg. Cat. Memb. N. A. 396.14.
1916. Entylia accisa E. E. carinata torva VanDuz. Check List Hem. 61.1716a.

We have a suspicion that this may be another variation of *E. concisa*. Walker notes the lower crests and the different colors but states that it, as well as *E. indecisa*, is "in general structure like *E. concisa*." If this similarity in "general structure" includes the peculiar shape of the caudal projection of the anterior crest, it would support this conjecture, but of this we can not be certain.

On the other hand, the lower crests and the prominent black and yellow markings strongly suggest *E. bactriana* and since we have examples of *E. bactriana* which exactly fit Walker's description, we are placing it as a synonym of Germar's species.

Butler recognized *E. accisa* as distinct on account of the shallower sinus and the blackish and yellowish coloration; Goding considered it a synonym of *E. sinuata;* VanDuzee makes it a synonym of Fitch's subspecies *torva* which latter he considers a variety of *E. carinata* Forst.

13. *Entylia indecisa* Walker = **Entylia bactriana** Germar.

1835. Entylia bactriana Germ. Silb. Rev. Ent. III:248.3.
1851. Entylia indecisa Walk. List Hom. Brit. Mus. 549.10.
1851. Entylia reducta Walk. List Hom. Brit. Mus. 549.11.
1877. Entylia indecisa Butler Cist. Ent. II:211.3.
1894. Entylia bactriana (part) Godg. Cat. Memb. N. A. 396.14.
1916. Entylia indecisa E. E. carinata VanDuz. Check List Hem. 61.1716.

We agree with Goding in making this a synonym of *E. bactriana* and considering *E. bactriana* a valid species. Certainly *E. indecisa* must be considered as identical with *E. accisa* since Walker indicates only color differences between the two. *E. bactriana* is the most abundant and most widely distributed species of the genus in New York, which is the type locality for *E. indecisa*.

Butler considered *E. indecisa* a variety of *E. accisa;* VanDuzee makes it a synonym of *E. carinata* with which he includes *E. bactriana*.

14. *Entylia reducta* Walker = **Entylia bactriana** Germar.

1835. Entylia bactriana Germ. Silb. Rev. Ent. III:248.3.
1851. Entylia reducta Walk. List Hom. Brit. Mus. 549.11.
1877. Butler Cist. Ent. II:211.5.
1894. Entylia bactriana (part) Godg. Cat. Memb. N. A. 397.15.
1908. Entylia reducta VanDuz. Stud. N. A. Memb. 105.
1903. Buckton Mon. Memb. 185.
1916. Entylia carinata var. reducta VanDuz. Check List 61.1716b.

We can not admit that this form is even a distinct variety as recognized by VanDuzee. We have reared it repeatedly from egg-masses of *E. bactriana* and have found all intermediate gradations from specimens answering Walker's description of *E. reducta* perfectly, to typical examples of *E. bactriana*, all from the same egg-mass.

15. *Oxygonia extensa* Walker = **Publilia concava** Say

1824. Membracis cocava Say Append. Long's Exped. II:301.3.
1835. Entylia concava Germ. Silb. Rev. Ent. III:249.4.
1851. Oxygonia extensa Walk. List Hom. Brit. Mus. 554.20.
1854. Entilia (sic.) concava Emm. Agr. N. Y., V:153, Pl. 13, fig. 10.
1866. Publilia concava Stal Analect. Hem. 388.
1869. Ceresa concava Rathv. Momb. Hist. Lanc. Co. Pa. 551.
1894. Publilia nigridorsum Godg. Cat. Memb. N. A. 399.20.
1903. Publilia grisea Buckt. Mon. Memb. 184, Pl. 39, figs. 5, 5a.

This species seems to have been entirely overlooked by all cataloguers of American Membracidae, although Walker lists it from three localities, "United States," "Cincinnati" and "Trenton Falls, N. Y." It has not been mentioned in literature, so far as we can discover, since its original description.

The writer in 1920 called Mr. VanDuzee's attention to the fact that it was omitted from his Check List and Catalogue and was advised that its omission was due to an oversight, as in the MS catalogue it had been entered under Ophiderma with the penciled note "equals *Publilia concava*" and under the latter species it was entered as a synonym.

We believe that VanDuzee's diagnosis is entirely correct. The genus *Oxygonia* (preoccupied, and now *Gelastogonia* as proposed by Kirkaldy, Ent. 37 : 279. 1904) as recognized by Fairmaire (see key to genera, Rev. Memb. p. 240) and Walker, would include Stal's genus *Publilia* (erected 1866). Moreover, it would include practically no other genus not known to Walker which could contain an insect such as he described. Again, *P. concava* is abundant throughout eastern United States and occurs in the two definite localities mentioned. The chief reason, however, for our decision is the fact that Walker's description of his *O. extensa* actually fits *P. concava* and does not fit any other known form of American membracid so far as we can discover.

Both Distant and Knight reported that the type specimen could not be located at the British Museum and it was thus impossible to secure a figure.

16. *Thelia conica* Walker = **Telamona conica** Walker. (Fig. 2).

1851. Thelia conica Walk. List Hom. Brit. Mus. 557.9.
1894. (?) Archasia conica Godg. Cat. Memb. N. A. 426.90.
1903. Archasia conica Buckt. Mon. Memb. 218.3.
1908. Telamona conica VanDuz. Stud. N. A. Memb. 73.
1916. Telamona (?) conica VanDuz. Check List Hem. 60.1657.
1917. Telamona conica VanDuz. Cat. Hem. 541.1657.

This species seems never to have been certainly recognized since its original description, and Mr. Distant was unable to locate the type specimen in the British Museum.

A species found in Mississippi agrees very well with Walker's meager description and is here figured. If it is not Walker's species it is new, and we prefer to consider it *T. conica*. It has not as yet been reported from the type locality given for *T. conica* (Florida) but there seems to be no reason why it should not occur there.

17. *Thelia angulata* Walker = **Ceresa femorata** Fairmaire.

1846. Ceresa femorata Fairm. Rev. Memb. 289.24.
1851. Thelia angulata Walk. List Hom. Brit. Mus. 558.10.
1851. Thelia tacta Walk. List Hom. Brit. Mus. 560.15.
1877. Eumela tacta Butler Cist. Ent. II:354.
1895. Stictocephala femorata Fowler B. C. A. 108.1.
1908. Ceresa femorata VanDuz. Stud. N. A. Memb. 41.14. Pl. 1, fig. 38.

Ceresa femorata Fairmaire was described from Mexico but is common through the southern portion of the United States where it has a wide range and shows considerable variation. The small size, very short suprahumerals, slender black-tipped posterior process, and the dark markings on the undersurface of the insect are usually characteristic. The first three of these characters were apparently considered by Walker as distinctive for *T. angulata*. We have examined a large number of specimens of *C. femorata* which fit Walker's description of *T. angulata* so closely that we cannot escape the conclusion that this was the species which he had before him. The type locality given for *T. angulata* is North Carolina and we know of no other membracid found in that region which can be considered as Walker's species.

Walker was familiar, of course, with the genus Ceresa, but apparently considered only those species which showed well developed suprahumerals as belonging to that genus for he places this, and the slender-horned species *C. constans* in the genus Thelia.

18. *Thelia substriata* Walker = **Stictocephala substriata** Walker. (Fig. 3.)

1851. Thelia substriata Walk. List Hom. Brit. Mus. 558.11.
1894. (?) Thelia substriata Godg. Cat. Memb. N. A. 414.64.
1908. Stictocephala substriata (error?) VanDuz. Stud. N. A. Memb. 45.4. Pl. 1, fig. 20.

It is evident from Mr. Knight's figure that VanDuzee was correct in assigning this species to the genus Stictocephala. It is equally evident, however, that the species which VanDuzee believed to be *substriata* and which he redescribed and figured in his "Studies in North American Membracidae" was not the one which Mr. Knight had before him as the type of Walker's species.

The species which VanDuzee recognized and which has been accepted as *substriata* by Smith, Metcalf, Barber and the writer in later publications, has a convex metopidium with apex farther front than in *inermis*, posterior process scarcely attaining tip of abdomen, clypeus scarcely longer than cheeks (Cf. VanDuzee Stud. N. A. Memb. p. 45) and a high sharp median carina (Ibid. Pl. 1, Fig. 20). Mr. Knight's figure shows an insect with an almost flat metopidium with apex much farther back than *inermis*, posterior process extending beyond the abdomen,

clypeus decidedly longer than genae and median carina not elevated above sides of dorsum as seen from a front view.

We have not seen an example which agrees with Walker's description and Mr. Knight's figure. We are convinced, however, that VanDuzee's *substriata* is distinct and should be renamed.

19. *Thelia rufivitta* Walker = **Stictocephala festina** Say.

1830. Membracis festina Say. Journ. Acad. Nat. Sci. Phila. VI:243.5.
1851. Thelia rufivitta Walk. List Hom. Brit. Mus. 559.12.
1851. Ceresa festiva (sic) Walk. List Hom. Brit. Mus. 1141.38.
1869. Stictocephala festina Stal Bid. Memb. Kan. 246.2.
1895. Stictocephala dubia Fowler B. C. A. 109.2.
1904. Stictocephala rubrovitta (sic) Snow. Kans. Univ. Sci. Bull. 2.349.
1908. Stictocephala festina rufivitta VanDuz. Stud. N. A. Memb. 46.

Stictocephala festina is very abundant throughout the southern states on alfalfa. In general collecting in a given locality about one-half of the males usually show the reddish color on the dorsum. We have never seen a female. The two hundred or more specimens of *rufivitta* which we have retained in our collection to show distribution as represented by the locality labels are all males. We can not admit this as a distinct variety.

20. *Thelia lutea* Walker = **Stictocephala lutea** Walker. (Fig. 4).

1851. Thelia lutea Walk. List Ham. Brit. Mus. 559.13.
1854. Gargara pectoralis Emm. Agr. N. Y. V: 157. Pl. 13. Fig. 12.
1869. Stictocephala lutea Stal Hem. Fabr. 11:24.

Stal fixed the status of this species when he indicated it as the type of his subgenus Stictocephala. The species shows some variation in structure and considerable variation in color. We should consider the form as figured by Mr. Knight as typical.

21. *Thelia tumida* Walker = **Xantholobus tumidus** Walker.

1851. Thelia tumida Walk List. Hom. Brit. Mus. 650.14.
1894. Cyrtolobus tumidus Godg. Cat. Memb. N. A. 433.111.
1916. C. (Xantholobus) (?) tumidus VanDuz. Check List Hem. 61.1699.
1917. Cyrtolobus (Xantholobus) tumidus VanDuz. Cat. Hem. 550.1699.

If we have determined this species correctly, it is very close to *X. muticus* Fabr. and may be a variety of that species. Superficially it differs considerably on account of its small size, shining yellow color, and lack of conspicuous markings. We have specimens from Florida and Mississippi. Florida is the type locality.

22. *Thelia semifascia* Walker = **Cyrtolobus tuberosus** Fairmaire.

1846. Thelia tuberosa Fairm. Rev. Memb. 307.6.
1851. Thelia semifascia Walk. List Hom. Brit. Mus. 561.16.
1903. Argante semifasciata (sic) Buckt. Mon. Memb. 190, Pl. 40, fig. 9; Pl. 41, figs. 1, 1a.
1916. Cyrtolobus tuberosus (part) VanDuz. Check List 60.1673.

Buckton's figures which were presumably made from the type specimen, since they are credited as being British Museum material from the type locality, seem sufficient for the identification of this species as *C. tuberosus* and it was so recognized by VanDuzee.

Both Walker's and Buckton's measurements, however, are small for typical forms of *C. tuberosus* as this species averages from eight to ten millimeters in length.

23. *Thelia constans* Walker = **Ceresa constans** Walker. (Fig. 5).

1851. Thelia constans Walk. List Hom. Brit. Mus. 563.21.
1869. Ceresa constans Stal Bid. Memb. Kan. 245.5.

Mr. Knight's excellent figures verify the diagnosis made by Stal and accepted by all later writers. Many specimens show the suprahumerals more recurved than the type drawn. The species may be generally recognized by its small size, reddish carina, and long slender, recurved, black-tipped suprahumerals.

24. *Thelia collina* Walker = **Telamona collina** Walker. (Fig. 6).

1851. Thelia collina Walk. List Hom. Brit. Mus. 565.35.
1877. Telamona collina Butler Cist Ent. II:220.2.
1903. Telamona pruinosa Ball. Proc. Biol. Soc. Wash. XVI:177. Pl. 1, figs. 7, 7a, 7b.

We have long been convinced that Ball's *T. pruinosa* was a synonym of *T. collina* and Mr. Knight's drawing leaves no doubt in our mind that this is the case. We have taken this insect commonly in New York, the type locality for *T. collina*, and the specimens identified by Ball as his *pruinosa* agree with Walker's description and with Knight's figures.

We can not understand VanDuzee's reason for placing Buckton's *T. turitella* as another synonym of this species (Cat. Hem. 541. 1953.). Buckton's description does not fit *T. collina*, he gives the type locality as Sanguanay, and his figure, Pl. 43, Fig. 7 (not Pl. 44, Fig. 6 as given by VanDuzee) resembles *T. collina* only in approximate outline.

25. *Darnis tripartita* Walker = **Carynota mera** Say. (Fig. 7).

1831. Membracis mera Say Journ. Acad. Nat. Sci. Phila. VI:310.10.
1851. Carynota mera Fitch Cat. Hom. N. Y. 48.650.
1851. Darnis tripartita Walk. List Hom. Brit. Mus. 576.15.
1854. Gargara majus Emm. Agr. N. Y. V:156. Pl. 13, fig. 6.
1856. Ophiderma mera Fitch, 3rd Rpt. Ins. N. Y. 465.191.
1878. Hypheus tripartita Butler Cist. Ent. II:343.
1894. Carynota strombergi Godg. Cat. Memb. N. A. 443.143.
1916. Carynota marmorata (part) (error?) VanDuz. Check List 59.1613.

The venation of the tegmina as shown in Mr. Knight's figure clearly places this species in the genus Carynota but we can not agree with VanDuzee in making it a synonym of *C. marmorata*. We have specimens of a southern form of *C. mera* from Kentucky, Mississippi and Florida, which have the brown band on the sides of the pronotum expanded into a dark triangle exactly as described by Walker and figured by Knight. Moreover, the original description does not mention, nor does Knight's drawing show, the light points on the metopidium and sides of the pronotum which are so characteristic of *C. marmorata*.

Our specimens show the extremity of the posterior process and the tips of the tegmnia brown as in the original description. These characters do not appear in the figure, due perhaps to the age and faded condition of the type specimen.

26. *Darnis stupida* Walker = **Carynota stupida** Walker. (Fig. 8).

1851. Darnis stupida Walk. List Hom. Brit. Mus. 577.16.
1878. Hypheus stupida Butler Cist. Ent. II:343.
1889. Ophiderma marmorata (error) Prov. Pet. Faun. Can. III:247.
1894. Carynota muskokensis Godg. Cat. Memb. N. A. 444.145.
1903. Hypheus albopicta Buckt. Mon. Memb. 135. Pl. 29, figs. 1, 1a.
1916. Carynota stupida VanDuz. Check List Hem. 59.1611.

There seems to be no question but that the above synonymy as adopted by VanDuzee is correct.

It will be noted, however, that Mr. Knight's figure does not show the small triangular yellowish spot at the margin of the pronotum which is mentioned by Walker in the original description and which is present in all of the specimens of the species which we have seen.

27. *Aconophora lineosa* Walker = **Platycotis vittata** Fabricius.

1803. Centrotus vittatus Fabr. Syst. Rhynch. 20.23.
1858. Aconophora lineosa Walk. List Hom. Brit. Mus. Suppl. 134.
1917. (?) Aconophora lineosa (Probably a Platycotis) VanDuz. Cat. Hem. 557.1722.

Mr. Distant was unable to locate the type of this species in the British Museum collection so that our recognition must be based only on comparisons. Walker gives as the type locality "North America," but our experience has been that this designation by Walker almost always refers to the United States or Canada, since his Mexican and Central American species are usually definitely indicated as to country. We are inclined to believe, therefore, that the species in question should be included in our list.

The genus *Aconophora* has not as yet been reported from the United States but the genus *Platycotis* (which at the date of Walker's catalogue had not been split off from *Aconophora*) is found in this country and in Canada. We have carefully compared Walker's description of *A. lineosa* with the descriptions or with specimens of all species of Aconophora and of Platycotis found in the United States and Mexico and find that it best fits the horned form of *P. vittata* as represented in our southern States.

28. *Entylia impedita* Walker = **Entylia carinata** Forster.

1771. Cicada carinata Forst. Nova Spec. Ins. Cent. I:67.
1858. Entylia impedita Walk. List Hom. Brit. Mus. Suppl. 137.
1917. Entylia carinata Van Duz. Cat. Hem. 553.1716.

Walker's meager description of *E. impedita* will fit almost any specimen of any species of Entylia, since the characters which he gives are common to the genus.

In our Canadian material the two prominent ridges on the anterior elevation of the pronotum, the brown and punctured basal half of the tegmina, and the vitreous hind wings, are most characteristic in the forms which we determine as *E. carinata* and we are therefore placing Walker's species as a synonym of this form.

E. impedita was described from West Canada.

29. *Hemiptycha diffusa* Walker = **Telamona diffusa** Walker. (Fig. 9).

1858. Hemiptycha diffusa Walk. List Hom. Brit. Mus. Suppl. 143.
1917. Telamona unicolor (part) (error?) VanDuz. Cat. Hem. 540.1651.

Mr. Edgar Knight wrote us under date of Jan. 30, 1920, that up to that time he had been unable to locate the type of this species owing to a new arrangement of the index at the British Museum. However, we have a Telamona from Canada

which agrees with Walker's description so perfectly that we feel sure of our identification.

We can not agree with VanDuzee in making this a synonym of *T. unicolor*. Walker's description fits the male of *T. unicolor* (*T. fasciata* Fitch) in a number of respects but Fitch's species is nearly twice as large as the species described by Walker and does not agree in the markings, especially those of the metopidium.

We figure a specimen from Waubanin, Canada. The type locality for *H. diffusa* is given as Orella, West Canada.

EXPLANATION OF PLATE IV.

Fig. 1. Front and lateral views of *Ceresa brevis* Walker. Drawing by Mr. Edgar Knight.

Fig. 2. Front and lateral views of *Thelia conica* Walker. Drawing by W. D. Funkhouser.

Fig. 3. Front and lateral views of *Thelia substriata* Walker. Drawing by Mr. Edgar Knight.

Fig. 4. Front and lateral views of *Thelia lutea* Walker. Drawing by Mr. Edgar Knight.

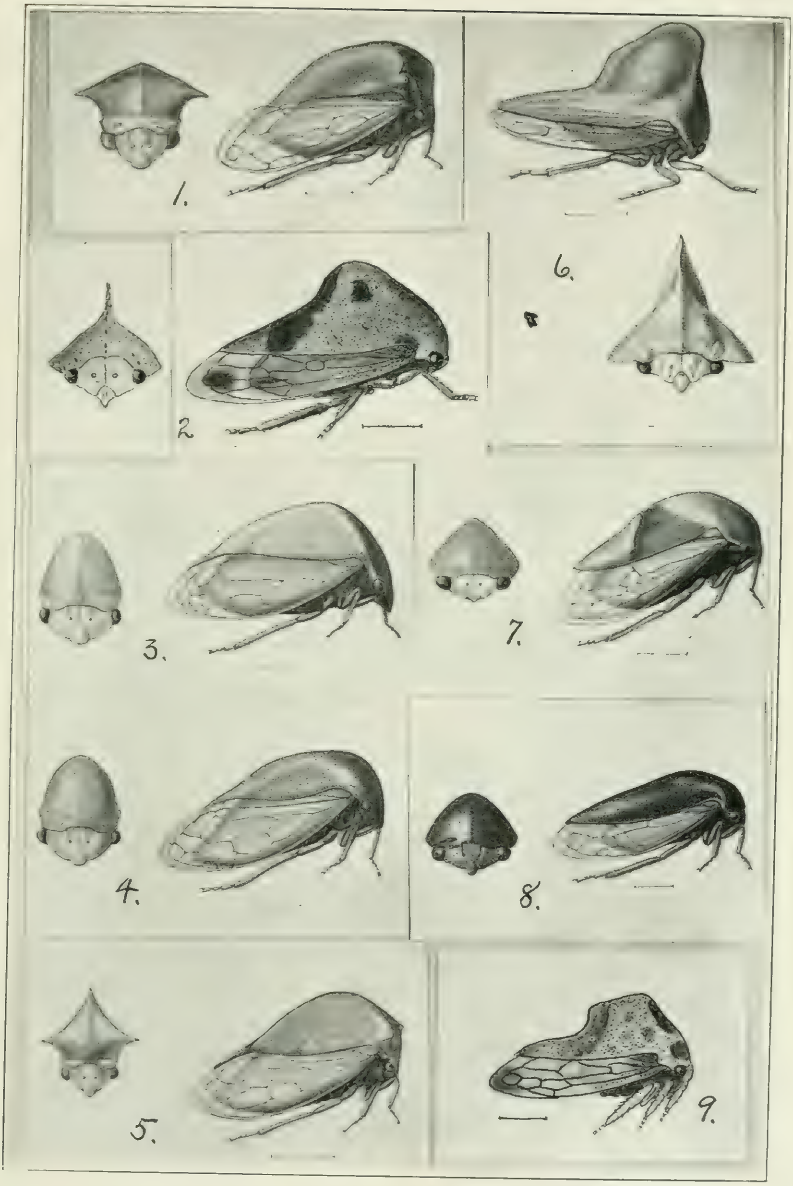
Fig. 5. Front and lateral views of *Thelia constans* Walker. Drawing by Mr. Edgar Knight.

Fig. 6. Front and lateral views of *Thelia collina* Walker. Drawing by Mr. Horace Knight.

Fig. 7. Front and lateral views of *Darnis tripartita* Walker. Drawing by Mr. Edgar Knight.

Fig. 8. Front and lateral views of *Darnis stupida* Walker. Drawing by Mr. Edgar Knight.

Fig. 9. Lateral view of *Hemiptycha diffusa* Walker. Drawing by W. D. Funkhouser.



W. D. Funkhouser

A CRITICISM OF THE "SEQUENCE" THEORY OF PARASITIC CONTROL.

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The theory of the action of entomophagous parasites with which I propose to deal in this paper, was first put forward by W. F. Fiske in 1910, in a comprehensive account of the parasites of the Gypsy and Brown-tail Moths*; and in the year following it was incorporated in the larger bulletin on the same subject written in collaboration with Dr. L. O. Howard.† From that time to this, the "Sequence" theory does not seem to have been subjected to any serious criticism; and there are good reasons for believing that it has exerted and still exerts considerable influence upon the thoughts and plans of entomologists concerned with practical problems of parasitic control.

The "Sequence" theory of the parasitic control was stated by Fiske (l. c. 1910, p. 13), as follows: "no one parasite is capable of effecting the necessary amount of control in an insect of the character of the gypsy moth, and capable of a similarly rapid rate of increase when unchecked by parasites; but a sequence of parasites, which will attack the insect in different stages of its development, and all the component members of which will work together in harmony, is absolutely necessary before the best results may be expected."

The arguments advanced in support of this statement in the publication cited (p. 14) are in the first place, "the fact that not in a single instance has one species of parasite been found sufficiently abundant abroad to bring about the percentage of destruction which will certainly be necessary in order to offset the six-fold rate of increase of the gypsy moth . . . "; and in the second place, the fact that, "there is not a single species of defoliating caterpillar, similar in habit to the gypsy moth, of which the parasites have been studied and which is

* W. F. Fiske, Parasites of the Gypsy and Brown-tail Moths introduced into Massachusetts. Boston, 1910.

† L. O. Howard and W. F. Fiske, The Importation into the United States of the Parasites of the Gypsy Moth and the Brown-tail Moth. U. S. Dept. Agr. Bu. Ent. Bull. 91. 1911.

controlled by them to any extent, which does not support a sequence of parasites similar to that which it is proposed to establish for the gypsy moth."

The method of operation deduced from the theory, outlined in the work cited and explained in greater detail in the 1911 publication, consists, in the case of the gypsy moth, in the establishment of a sequence of parasites, attacking different stages of the host and working in harmony, sufficient to eliminate each year 83.33 per cent of the population of the host insect; which, having an effective rate of increase of only six fold annually, would thus cease to increase in numbers, as a moment's reflection will show.

Now it may be conceded, for the purposes of this argument, that if it be shown that in nature, the control of injurious insects is invariably the work of a sequence of parasitic enemies, the establishment of such a sequence ought to be the main object of our practical operations, success without the formation of a sequence being extremely improbable if not impossible. It does not appear, however, that this has really been demonstrated by Fiske. It is indeed true, that among the vast multitude of entomophagous parasites, there are to be found species and groups of species attacking injurious insects in almost every stage of development; and that for any given host, investigation will usually—though not necessarily always—disclose parasites of the egg, parasites of the larva and parasites of the pupa. But from the fact that such sequences frequently exist in nature we cannot legitimately conclude that they are essential for the natural control of the host; or that, were they incomplete, the host would not be held in check. It may be that in many cases, one or two members of the sequence are really responsible for control, the other members being in fact negligible for all practical purposes.

It is certainly a fact, as shown long ago by Fiske for *Clisiocampa disstria** and recently by Picard for *Pieris brassicae*†, that many insects in their native homes are attacked by groups of parasites which seem to destroy a certain average proportion of hosts year after year, the combination of parasitic and other

* W. F. Fiske, A Study of the Parasites of the American Tent Caterpillar. New Hamp. Agr. Exp. Sta. Tech. Bull. No. 6, 1903.

† F. Picard, Contribution a l'etude des Parasites de "*Pieris brassicæ.*" L. Bull. Biol. France, Belgique, T. LVI, Fasc. I, 1922.

destructive influences, usually being sufficient to prevent the hosts from becoming overwhelmingly injurious. It does not seem, however, that the authors who have studied these cases have shown clearly in just what manner normal conditions are restored when a disturbance of the natural equilibrium results in an abnormal increase of the injurious species: in other words, they do not tell us just how an outbreak of the pest is reduced. But this is precisely the point of greatest interest to us; for we can scarcely hope to reproduce *in toto* in the new home of an introduced pest the conditions under which it lives in a state of average abundance in its native country, these conditions being the result of the action and interaction of a vast multitude of various factors throughout the course of many ages. All we can hope to do is to parallel in the new home of the insect the process leading to the reduction of an outbreak in the native home. But since, as we have seen, the authors quoted do not provide us with definite information as to this process, it would seem, that the statement cited above, that "no one parasite is capable of effecting the necessary amount of control in an insect of the character of the gypsy moth . . . but a sequence of parasites . . . is absolutely necessary before the best results may be expected," arising as it does out of observations which either do not give the information essential for such a deduction, or concern a state of affairs other than that presented by an outbreak, may be considered for the present as not proven.

It is now necessary to consider with some care, the implications of the "Sequence" theory; for, once these are fully realized, the limitations of this theory, as a basis for practical operations, immediately become evident.

As we have seen, according to Fiske, the rate of increase of the gipsy moth being six fold per generation, a parasitism of 83.33 percent is necessary, in order to secure control. To put this into a more general form, if the effective rate of reproduction of the host per generation be "h," the proportion of hosts parasitized must be constantly equal to $\frac{\text{H–I}}{\text{h}}$. Under these circumstances, the host population will obviously remain stationary, generation after generation. No further increase will occur.

But, if, as the theory explicitly postulates, the host remains stationary, then the parasite population must also remain stationary; for if the parasite population increases in each generation, then the numbers of the host will obviously not remain constant but will decline, as could very readily be shown. And if the parasite population remains constant, the effective reproductive rate of each of the species in the sequence must be equal to "I"; from which it follows, that if the natural reproductive rate of any given member of the series were "s," per generation, ("s" being greater than "I"), then a proportion represented by $\frac{s-I}{s}$, would have to be eliminated by some cause or causes, in every generation, after the death of the parasitized hosts. And if, as the theory postulates, the total percentage of destruction accomplished by the sequence remains constant, then, other things being equal, a similar elimination of offspring would have to occur for each member of the sequence.

However, if, at any given stage in the development of the population of a parasite, we postulate an elimination of a proportion of the offspring such that the parasite will not thereafter increase in numbers, but will remain stationary, why should this elimination not be postulated for every other stage? On the other hand, if such an elimination fails to occur during a large number of generations following the introduction of the parasite, what reason is there to suppose that it will ever occur? In other words, we may reasonably suppose that the factors responsible for the destruction of the required proportion of the parasite population will operate continuously in every generation from the moment of introduction, that they will never operate, or finally, that they will operate only at irregular intervals. But what reasons have we for supposing, that the eliminating factors will begin to operate only after the parasite populations have increased sufficiently, so that during a given generation, the host is held stationary; and that at this precise moment, the eliminating factors intervene, so that after this point, the parasite is also held stationary. For this is precisely the supposition implied in the theory. "It goes without saying, "wrote Fiske, (l. c. 1910, p. 22) "when the habits of the parasites are taken into consideration, that the few paltry thousands which it has been possible to secure . . . must be allowed sufficient time to increase to the millions and billions necessary

to cope with the tremendous quantities of gypsy moths which are everywhere in evidence throughout the infested district. Fortunately, this increase . . will be by geometrical progression."

Now, if a parasite can increase by geometrical progression up to the point where the proportion of parasitized hosts is $\frac{h-I}{h}$ what reason is there for supposing that it will not increase further, to the relatively slight extent necessary for the practical extermination of the host?

Later in this paper, an attempt will be made to answer these questions. Before doing so, however, it must be noted that by the theory we are discussing, the increase to this point is not assumed for a single species of parasite, but for a group of parasites, no one of which, taken separately, destroys the required proportion of hosts; this proportion being attained by their combined efforts. But this fact is of no importance, the arguments concerning the increase of a single species being equally applicable to a group of species working together.

Nevertheless, for reasons which will appear in a moment, the question of the action of a sequence of parasites requires special attention.

If, as postulated by the "Sequence" theory, we have a group of parasites attacking the host, either, one or more of these parasites will have a rate of reproduction equal to or greater than, the rate of reproduction of the host; or else the rate of reproduction of each one of them will be individually less than the rate of reproduction of the host.

But if the rate of reproduction of any one of the parasites is equal to or greater than the rate of reproduction of the host, then this parasite alone will not merely increase to the point where it parasitizes a proportion of the host population equal to $\frac{h-I}{h}$, but will in many cases increase further to the point where complete control is secured, the host population being for practical purposes exterminated, by the unaided efforts of the species in question. In such a case, therefore, a sequence of parasites would not be necessary in order to secure the best results; which is contrary to the theory we are discussing.

If, on the other hand, the rate of reproduction of each of the parasites in the sequence is individually less than that of the host, then let there be at the beginning of the experiment,

"p" parasites with a reproductive rate of "a", "p" parasites with a reproductive rate of "b," "p "parasites with a reproductive rate of "c," "p" parasites with a reproductive rate of "d," and so on, the colonies being assumed to be equal in numbers merely to facilitate calculation; and let the reproductive rate of the host be "h."

The investigation of this case is a rather complex matter; but the results, obtained by mathematical operations which need not be given here, may be resumed as follows:

If, at the beginning of the experiment, there are "n" hosts with a reproductive rate of "h," "p" parasites with a reproductive rate of "a," "p" parasites with a reproductive rate of "b," "p" parasites with a reproductive rate of "c," "p" parasites with a reproductive rate of "d," and so on, each reproductive rate being singly less than "h" in numerical value, then the proportion which must exist between the initial number of hosts and the initial number of each species of parasite, must not be greater than that given by the equation,

$$\frac{n}{p} = \frac{a}{h-a} + \frac{b}{h-b} + \frac{c}{h-c} + \frac{d}{h-d} + \text{etc.}$$

if the parasites are ever to increase to the point where control is secured.

Thus, take a case where we have a host whose reproductive rate per generation is equal to 20, and let there be at the beginning of the experiment equal numbers of 10 species of parasites whose reproductive rates are respectively equal to 19, 18, 17, 16, 15, 14, 13, 12, 11, and 10, their combined reproductive rates being thus 145, which is more than 7 times the reproductive rate of the host—the case chosen being thus exceptionally favorable to the "Sequence" theory. Then in this case, if control is to be effected, there must not be less to begin with, than 10 parasites of each kind for 485.7 hosts; and if control is to be effected within measurable time, then the number of parasites must be greater, in proportion to the number of hosts, than the number given by the formula. Otherwise control, though theoretically possible, will occur only after an infinite number of generations.

Again, let there be 20 parasites instead of 10, with reproductive rates of 19, 18, 17 . . . 1, respectively, in this case there must not be at the beginning of the experiment more than 51.93 individuals of the host for one individual of each separate

species of parasite, that is, there must be at least 20 individuals of all the species of parasites taken together, for every 51.93 individuals of the host, if control is ever to occur and a greater number of parasites. if it is to occur within measurable time.

It is, of course obvious, that no such numbers of parasites as are required to produce such proportions between the host population and the parasite population, at the beginning of the experiment, can really be introduced.

Thus, to summarize briefly the results obtained from our examination of the sequence theory, either the reproductive rates of one or more of the parasites introduced are equal to or greater than the reproductive rate of the host; and in this case a sequence is not necessarily indispensable; or else the reproductive rates of each of the species introduced is individually less than the reproductive rate of the host; and in this case the method implied in the sequence theory cannot be put into practice.

Nevertheless, although the ''Sequence'' theory as put forward by Fiske, is not universally applicable, i. e., is not acceptable as a complete general theory of parasitic action, this hypothesis is valid within certain definite limits. As we have seen, the theory implies that after the requisite time for multiplication has been allowed, the group of parasites forming the sequence will have increased to the point where the result of their attack, added to the destructive effect of nonparasitic influences, will be the reduction of the effective reproductive rate of the host to I; after which they will cease to increase further, so that a permanent equilibrium between host and parasite will be secured.

The conditions required in order that this may be possible, are as follows:

1. The action of the parasites must be so limited by factors acting in space and time, that the percentage of hosts destroyed can never rise above a certain average figure.

2. The total maximum percentage destroyed by non-parasitic causes, must be such that the effective reproductive rate of the host is reduced to I.

3. No one parasite is capable of destroying the required proportion of the host population, even in conjunction with non-parasitic causes; the combined maximum efforts of all the species forming the sequence being necessary.

Suppose, for example, that we have a host which continues to oviposit over a considerable period of time, so that there results a series of overlapping life cycles. In this case, which is almost universal, we will find in the field during a considerable period of time, almost all stages of the host insect; any given stage occurring in nature during a period much longer than that required for the passage through this stage for any given individual.

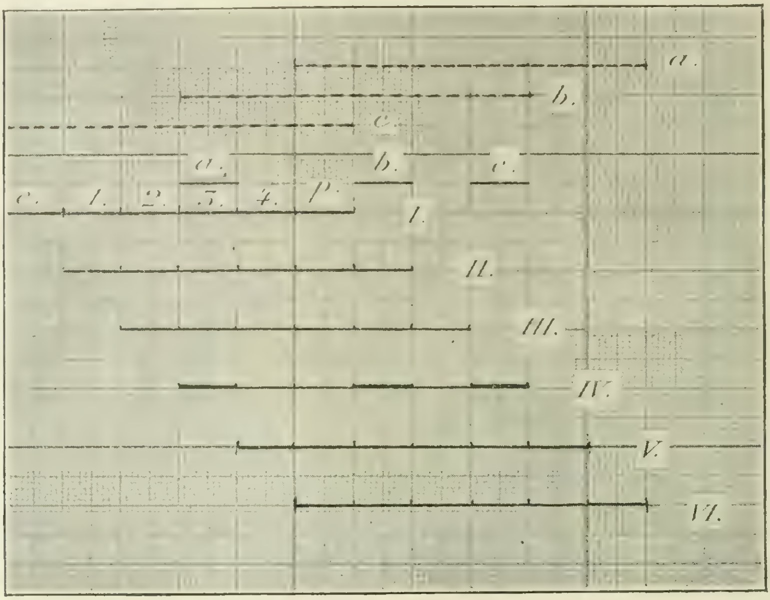

Fig. 1. Distribution of Host and Parasites in Time. I–VI, 6 overlapping life cycles of the host insect, comprising each, the egg stage (e), four larval stages (1–4) and pupal stage (p); a, b, c, periods of oviposition of three parasites, attacking respectively the egg, third larval, and pupal stage. If the oviposition periods are as shown in the upper dotted lines, any one of these parasites is potentially capable of exterminating the host. If they are as shown by the lower short solid lines, no one of the parasites can destroy more than 16.6% of the host population.

Now if a parasite attacks the host in any given stage; but does not continue to oviposit during the whole period when this stage is available, then it will never succeed in destroying more than a certain fraction of the host population, the fraction destroyed depending on the relation between the oviposition period of the parasites and the period during which the host is to be found in the field in the stage attacked by the parasite considered. The diagram in Figure 1 will make this clear.

This covers the question of the distribution of host and parasite in time; but their distribution in space is equally important. Here, as before, there may be certain cases in which the parasitism by a given species is necessarily limited to a certain proportion of the host in a given stage. For example, as has been shown, the parasites attacking the egg masses of

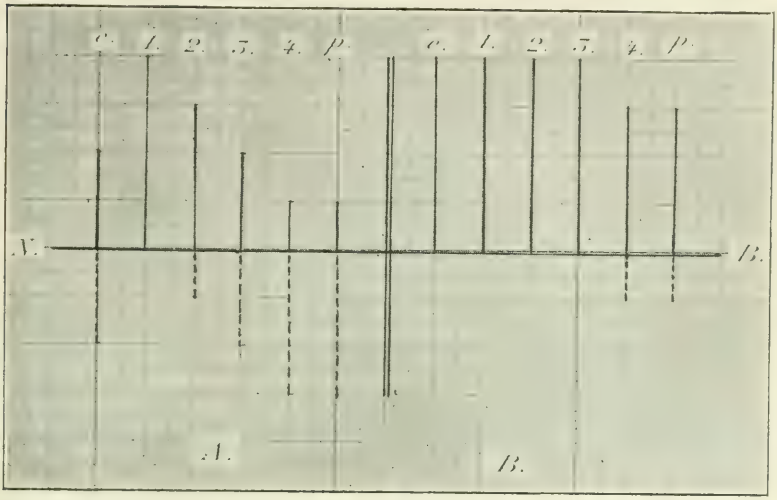

Fig. 2. Distribution of Host and Parasites in Space. N.-B., line representing a natural spatial barrier. The vertical lines, e, 1-4, p, represent the distribution of the host in space in the egg, first to fourth larval, and pupal stages. The solid part of each line, above N.-B., represents the proportion of the total host population available for attack by the parasite of the stage in question; the broken part of each line, below N.-B., represents the proportion of the host population protected by the natural barrier in this stage. Thus, in A, a parasite attacking the 1st stage larva might eventually exterminate the host; whereas the parasite of the pupa could not do so. Again, if A and B represent alternate generations, in which the proportion of host protected in the various stages differs to the extent shown, it will be evident that although the parasites of the egg, 1st, 2nd and 3rd stage larvae could attack all of the host population in any of these stages, in generation, B, in generation A only the parasite of the 1st stage larva could attack the whole population of the host. All of the other parasites would be more or less limited in their power of attack in generation A.

certain injurious insects are unable to oviposit in the eggs beneath the external layers. For this reason, as our second diagram shows, these parasites can never rise above a certain figure in relation to the total population of the host.

Again, the spatial distribution of the host in the stage attacked by a given parasite, may be regularly favorable to the

parasite in one generation and as regularly unfavorable in the next, in the case of hosts having more than one generation per annum. Consequently, the effectiveness of the parasite will be constantly reduced in alternate generations. The second diagram represents also this state of affairs.

Without taking into account any of the more complicated examples which might be given, it will be evident that there really are cases, in which the percentage of parasitism by a given species may never rise beyond a certain maximum point; as the Sequence theory implies. If, in addition, all of the parasitic species attacking a given injurious insect are so limited, either in space or in time, or in both, and if, furthermore, the maximum percentage which can be destroyed by all taken together, in conjunction with non-parasitic factors, is such, that the effective reproductive rate of the host is reduced to I; then we shall have a case to which the Sequence theory completely applies.

But it is also evident that such cases, far from being the general rule, as the Sequence theory implies, are probably rare in nature. For although any given parasite may be more limited in space and time than the host in the particular stage which the parasite attacks, this will not necessarily be true of all of the species attacking the host in question; nor even of the majority of the members of the parasitic sequence. And as we have seen, if one single species in the sequence is not in fact so limited in its power of attack, then there is no reason to suppose that if it can increase to the point where it destroys an appreciable fraction of the host population, it will not increase further to an extent sufficient to produce what we may term for practical purposes, extermination.

Again, admitting that the population of a given host in the country of origin is held stationary by the combined effect of parasites and non-parasitic influences, it must still be remembered that in a new country conditions may be very different. The effect produced by the sequence of parasites may be the same, but the elimination by non-parasitic causes may be greater or it may be less. In the former case, extermination, and not merely control, will result; in the latter, the host will continue to increase and spread, in spite of the establishment of the sequence. Because of the absence of specific secondaries, or other causes unfavorable to the parasites; or of the presence of

more favorable conditions, the parasites themselves may be less restricted in the new environment than they were in the old, in which case the parasitic cycle will be completed and extermination of the host will occur. Or, again, the parasite in the new country may prove to be more restricted than it was in its original home; and then the action of the parasites will be insufficient to prevent the increase and spread of the host.

In short, in the opinion of the writer of this paper, the "Sequence" theory implies the existence of an equilibrium between host and parasite, too delicate and too unstable to be permanent.

Nevertheless, the fact that the sequence theory is limited in its application does not mean that the introduction of parasites forming a sequence is useless or inadvisable. On the contrary, there is no doubt that this method—which is only one among many brilliant contributions made by Fiske to the study of natural control—ought to be followed as far as possible in all attempts to bring about parasitic control. But this is not because in order to obtain control, we must have a series of parasites attacking different stages of the host and working together in harmony. It is simply because, by introducing a number of parasites, we are more likely to hit upon a species whose reproductive rate is equal to or greater than that of the host and which for that reason will eventually produce control, the parasites chosen being preferably those attacking the host in different stages of its development, in order that a conflict between species may not result to the detriment of the action of the parasites as a whole.

It is true, as could easily be shown, that if the reproductive rates of the several parasites are equal and if they are equally unrestricted in their choice of environments, no better results will be obtained by the introduction of "p" parasites of one species, "p" of a second and "p" of a third, than we obtain by introducing "3p" of any one of these; but if their choice of environments differs slightly, then the more species we introduce, the more likely we are to provide parasites fitted to all of the various environments in which the host is found.

Again, curious as this may seem, the mere fact that the reproductive rates of different parasites may differ, is also extremely advantageous: for it can be shown that "p" parasites with a reproductive rate of "a," "p" with a reproductive

rate of "b," and "p" with a reproductive rate of "c," will overtake and control the host more rapidly—other things being equal—than "3p" parasites of one species, whose reproductive rate is equal to $\frac{(a + b + c)}{3}$.

These advantages, though undoubtedly real and important, are not those implied in the "Sequence" theory and claimed by its author for the method deduced from it. Nevertheless, since they exist—since on several grounds the introduction of a sequence of parasites of an introduced pest is desirable—it may be asked, what real objection can there be, to the "Sequence" theory as a basis for practical work; why should we not continue to take this theory for granted since the method deduced from it turns out after all to be the best method?

The answer to this is, that the "Sequence" theory as it stands is objectionable because of its implication that a sequence of parasites is not merely desirable, but absolutely essential, if parasite control is to be obtained in any given case. Success in practical operations is thus made to depend entirely upon the establishment of a perfect sequence; failure is considered to imply, that the sequence of parasites is incomplete, from which it naturally and inevitably follows that if, after waiting for what seems on vague general grounds to be a reasonable period of time after the introduction of a number of parasites, control does not occur, we feel obliged to conclude that the sequence of parasites introduced is still incomplete; and, consequently, that more species of parasites must be introduced.

The fact is, however, that the attainment of control by introduced parasites primarily depends, not simply and solely on the establishment of a perfect sequence, but rather on the ratio between the rates of reproduction of the host and the parasite; while the time required for control depends, on the one hand, on the factor just mentioned and on the other, on the ratio between the initial number of parasites introduced and the initial number of hosts.*

In the opinion of the writer, one of the most difficult points to realize in connection with parasite work, is the enormous disproportion which exists between the initial population of the introduced parasite and the initial population of the host in

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* Assuming that the ratio between the sexes is the same in host and parasite and that only one egg is deposited by the parasite in each individual of the host attacked, i. e., neglecting the factor of super-parasitism.

the infested area. That this disproportion exists, everyone knows. What is difficult to grasp is its significance and more especially the fact, that because of it, control may require a long period of time; and yet eventually occur to such a degree that the host is for all practical purposes exterminated.

Thus, if at the beginning of the experiment, we have 100 million hosts and 2000 parasites and if the reproductive rate of the parasite is twice as great as the reproductive rate of the host, about 15 generations would be required for control, which, in the case of an insect like the Gypsy Moth, would mean 15 years and 7½ years in the case of an insect like the Corn Borer. Nevertheless, unless the effect of certain factors acting in nature were on the whole very unfavorable to the parasite and at the same time very favorable to the host, which is on general grounds unlikely, control would certainly occur.

Once this conception of the slow but certain action of a specific parasite—a conception lost sight of in the "Sequence" theory—has been thoroughly grasped by the entomologist, he will not allow himself to become discouraged because results are slow to follow the establishment of parasites; and if he has observed that the species already introduced are increasing in a reasonably satisfactory manner, he will be in no hurry to introduce additional species which might possibly come into conflict with those already in the field, on the pretext of completing the sequence.

Again, according to the "Sequence" theory, the object of the introduction of parasites is primarily to prevent the host from increasing further; this object being attained by the establishment of a series of parasites whose action will result in the reduction of the reproductive rate of the host to one fold. The entomologist who takes this theory as a basis for practical work will therefore be led to consider his work a failure, if he observes that the host continues to increase; and this may also induce him to attempt the introduction of additional species whose only effect may be to retard the process of control by a conflict arising between the new species and those already established.

But, as has been shown, the attainment of the type of control where the host ceases to increase, remaining numerically stationary, is perhaps in many cases an impossibility. In reality, the idea that this is the prime object of parasitic introduction is at least partially erroneous. The object of parasite introduction—or at all events the most probable satisfactory result of parasite introduction—is not the reduction of the

reproductive rate of the host to such an extent that it thereafter remains numerically stationary; it is the extermination of the host, for all practical purposes. Finally, the idea that the parasite will affect the multiplication of the host to any perceptible extent, seems also without any solid foundation. The truth is, that even in a perfectly successful case of parasite introduction, we may expect the host to go on increasing from generation to generation, becoming year after year more numerous and increasingly destructive; until it has reached a certain maximum point, at which it will suddenly disappear. The entomologist who expects that the parasites he has introduced will arrest the increase of the host is likely to be disappointed; and if he judges his work to be unsuccessful because the host continues to increase and spread, although the percentage of parasitized hosts is constantly rising, he may be completely mistaken.*

We may therefore conclude that the "Sequence" theory cannot be considered as a valid general theory of parasitic action; since it applies simply to a very limited group of special cases, in which we have what may be called for the present, "blocked cyclical" parasitism, since it results from the interruption of the multiplication of the parasites at the expense of the host, by unfavorable factors, which come into action at the precise moment when the effective reproductive rate of the host insect has been reduced to unity. That such cases exist in nature, cannot be denied. But they are much less important for the theoretical study of parasitic action, than pure or uninterrupted cyclical parasitism, of which they are simply derivatives.

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*Note.—If, as has been frequently alleged, the behavior of injurious insects parasitized in the feeding stage differs in no respect from the behavior of unparasitized individuals, then parasites will not produce any *reduction of damage* until the extermination point is reached. But Crossman seems to have shown (S. S. D. A. Bull. No. 1028, March 13, 1922) that larvæ of the Gypsy Moth parasitized by *Apanteles melanoscelus* have a feeding capacity of only one-third to one-half that of normal individuals; from which it follows, that in such cases, toward the upper end of the parasitic cycle, when the percentage of parasitized hosts is high, the amount of damage done by the injurious insect will be considerably less than it would be, were all the larvæ of the host healthy. Nevertheless, as the numbers of the host continue to increase, the actual aggregate damage in a generation where 50 per cent of the hosts are parasitized, may be greater than in the preceding where only 30 per cent were parasitized, the increase in the number of hosts being only partly compensated by the reduction in the feeding capacity caused by the increase in the proportion of parasitized hosts. A reduction in aggregate damage would thus only occur when the reduction in feeding capacity more than compensates the effect of the increase of the host; although, other things being equal, if the increase of the hosts manifests itself in spread rather than in increased concentration, the damage per unit area may fall, as a little reflection will show.

THE LIFE HISTORIES AND STAGES OF SOME HEMEROBIIDS AND ALLIED SPECIES (NEUROPTERA)*

Roger C. Smith.

Hemerobiids, which are very closely related to the Chrysopids, were frequently observed by the writer in his study of the Chrysopids, and he early undertook their study as opportunity was afforded. The account here given follows the general plan used in the discussion of the Chrysopids (Smith, 1922B) and where characteristics are practically identical, the reader is referred to this paper for further details.

This account is based on random collections and rearings covering a period of about six years. The greater part of this work, including the making of the photographs, was done while the writer was connected with the Bureau of Entomology, Division of Cereal and Forage Insects, at the Charlottesville, Virginia, laboratory. The notes and photographs made at that time are used with the kind permission of Mr. W. R. Walton, Chief of the Division, and Mr. W. J. Phillips, Director of the laboratory. Further collections and rearings have been made at Manhattan, Kansas.†

These families of insects are unfamiliar to most people, since they are rare in nearly all localities. They are, however, widely distributed in the tropical and temperate zones, occurring, as far as known, all over the United States. They are of importance chiefly because of their destruction of plant lice and other small, soft bodied forms for food which makes them predominately beneficial, and also because of their phylogeny, morphology, and life histories.

There has been some question for many years, as pointed out by Tillyard (1916), as to what constituted a Hemerobiid. The genus Hemerobius as used by Linnaeus (1758) included in addition to some Hemerobiids and more closely allied forms,

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† The writer wishes to acknowledge his indebtedness to Mr. S. Fred Prince, for the plate of drawings; to Messrs. Edgar Davis and Charles Hadley for assistance in collecting and rearings; to Dr. Nathan Banks for identifications at various times of all species mentioned.

some Sialids, Chrysopids, a Psocid, and similar forms. These more distant forms were soon removed and made the basis of families. This process of removal of species or genera and raising them to families has followed additions to our knowledge of the species. More recently the following families have been removed from what was included in the Hemerobiidæ in Bank's Revision (1905), the Sisyridæ, Sympherobiidæ, Dilaridæ, Berothidæ, and the Polystoechotidæ. Tillyard (1916) defined the family and its relatives, since which Comstock (1918) removed Lomamyia and Sympherobius and placed them in separate families because of their venation.

Because of superficial resemblance, most species of these families may be confused with some Chrysopids, especially Ereomochrysa, some Trichoptera, and certain small moths. Upon close scrutiny, however, the coloration, morphology, and manner of flight will be found to be distinctive. These insects are often called "Brown lace wings" or "smaller lace wings," while the Chrysopids are known as "green lace wings," or merely "lace wings." They are, however, so similar to the Chrysopids in habits and life history that in discussing them, a comparison with these better known insects will probably be the best system to follow.

The chief contributions to our knowledge of these families are contained in the writings of Fitch, Hagen, Banks, Moznette, Tillyard, and Comstock. Moznette (1915) has given the only account of a life history.

The facts and discussions here presented are based on the collections and rearings indicated in Table I.

TABLE I.

Name of Species	Localities and Some of the Collection Dates	Habitat or Plant on Which Taken	Stages Seen
Lomamyia flavicornis Walk.	Manhattan, Kans., 6–16–20; 6–17–20	Oak	Adult and Egg
Hemerobius conjunctus Fitch.	Charlottesville, Va., 10–2–19	Pine	Adult
Hemerobius humuli Linn.	Ithaca, N. Y., 7–31–16; 9–10–16 Charlottesville, Va., 4–8–19; 4–23–19 Manhattan, Kansas, 9–18–20; 6–26–22	Oak, spiraea Oak, apple, elm, spiraea Pine; alfalfa	All stages
Hemerobius stigmaterus Fitch.	Ithaca, N. Y. (No collection data) Charlottesville, Va., 11–24–19 Manhattan, Kansas, 4–7–20; 5–6–21; 6–13–20; 6–17–21	Oak, apple, alfalfa Oak, pine, alfalfa	All stages
Sympherobius amiculus Fitch.	Charlottesville, Va., 4–28–19; 6–9–20; 6–17–20 Manhattan, Kansas, 6–12–20	Apple Oaks	All stages
Sympherobius barberi Banks	Manhattan, Kansas, 7–7–20; 10–14–20; 5–12–20; 7–22–20; 23–22	Oak and alfalfa	All stages
Micromus posticus Walk.	Ithaca, N. Y., 9–4–16; 10–1–16; 7–31–16 Charlottesville, Va., 7–3–19; 7–8–19; 5–30–19 Manhattan, Kansas, 3–5–20; 10–10–20; 6–26–22	Oak Apple Oak and alfalfa	All stages

DESCRIPTION OF EGGS.

The eggs of the above species (see Plates V–VII) are elongate-elliptical in shape, being approximately twice as long as the greatest diameter, and without stalks. At the anterior end there is a fairly prominent, white, button-like micropyle. The surface is smooth, except that in most species there is a series of minute, raised, oblong, whitish, somewhat gelatinous flecks or reticulations arranged in regular rows. In *M. posticus* these reticulations are absent, the chorion appearing perfectly smooth and shining; the pearly iridescence, however, may indicate very fine striations on the surface. In Lomamyia the reticulations are connected in the form of hexagons, giving the appearance of a minute hexagonal network covering the egg.

The color varies both with the genera and the stage of embryonic development. The eggs are predominately grayish in color, with a tinge of yellow. In eggs of Lomamyia there is a tinge of purple or maroon observed. The eggs of *M. posticus* are predominately pink.

The eggs are glued to the substratum on the dorsum, or what will be the dorsum of the embryo. The chorion here is smooth, lacking the reticulations and surface markings found on the upper surface. It is apparently thinner, more transparent, and gelatinous, which causes the egg to adhere so securely that it is frequently torn or crushed in an effort to remove it.

The eggs are not often found in the open. The writer has found them on apple buds (Fig. 4, Pl. V) in pits and crevices of bark, around buds or near ends of twigs, and on leaves infested with aphids. They may be confused with some Syrphid eggs, which are deposited in the same habitat. However, these Syrphid eggs are usually larger and the surface markings are far more prominent, approximately six times the size of those on Hemerobiid eggs. They can be readily distinguished from eggs of our known Chrysopids in that the latter are borne on long hyaline stalks. The eggs proper are slightly smaller but of the same shape as the Chrysopids.

HATCHING.

The writer (1922) has described hatching in *Micromus posticus*, and there is no essential difference in the manner of hatching in the different species studied, all making use of a specialized knife blade structure to rupture the chorion (See Figs. 3 and 4, Pl. V). The distinctness with which the burster can be seen just before hatching varies somewhat. In some instances it is rather indistinct, but generally it is prominent, resembling a small thorn beneath the chorion. The bursters of the different genera differ somewhat though they are of the same general type. The hatching process is very similar to that of the Chrysopidæ. The black eyes of the embryo are generally quite distinct before hatching (Fig. 3, Pl. VI). During the hatching process, a rhythmic pulsating of the dorsum of the head can be observed. This may be an accessory pulsating center, functioning to assist in the circulation of the blood, but it either ceases or is no longer visible externally after the cuticula hardens. It may also assist in pushing the burster through the chorion.

DESCRIPTION OF LARVAE.

Larvae of these species resemble chrysopid larvæ rather closely. They are somewhat shorter, being 4 to 7 mm. in length, and noticeably more slender, being only 0.4 to 1.5 mm. wide at the metathorax. They are often described as spindle-shaped, being broadest in the middle and tapering at both ends, especially at the posterior. The colors do not develop until the larvæ are about five hours old, and then only faintly. The predominant color in newly hatched larvae is gray or smoky gray. The spots are usually some shade of red, varying from very light pinks to deep reds. Occasionally a tinge of purple or a shade of brown may be noticed. The coloration is influenced somewhat by the viscera and intestinal contents also.

The head is somewhat smaller in proportion to the size of the body than in Chrysopid larvæ, being 0.3 to 0.5 mm. in width at the eyes in fully grown larvæ. The eye spots, which contain five circular ocelli very unequal in size, are located in a prominent black spot at the outer anterior margins of the head. The jaws are quite stout at the base and extend usually more nearly straight forward than in the Chrysopidæ, and then bend rather sharply mesad near the tips. The antennæ are relatively shorter and stouter than in those of Chrysopid larvæ. They consist of two or three very unequal segments, the distal segment being pointed but not always bearing a seta. The labial palpi are three segmented, the terminal segment being pointed instead of rounded as in the Chrysopidæ. The dorsal head markings vary in the different instars and in the different genera. There is usually a black or dark, smoky gray border at each side of the head and a black median bar, otherwise the head is light gray. The head of young larvæ is either a uniform smoky gray color, without definite markings dorsally, or there are three more or less triangular black spots separated by light gray areas.

The body is divided as in the Chrysopidæ into three thoracic and ten abdominal segments, each of which is more or less distinctly divided into a small anterior and a much larger posterior subsegment (Fig. 1, Pl. V). The prothoracic subsegments are very much more elongated than in the Chrysopidæ known to the writer. The larvæ, because of this elongated prothoracic segment, appear to have a prominent neck. The

first abdominal segment is more nearly comparable to the other abdominal segments than in the Chrysopidæ and is, therefore, readily distinguished. The posterior abdominal segments are modified similar to those of the Chrysopids into a tapering tubular structure which is used for walking.

The dorsal blood vessel is plainly visible in the mid-dorsal line as in the Chrysopids. The lateral tubercles, so prominent in most Chrysopids are exceedingly small and inconspicuous or entirely lacking in the Hemerobiids studied by the writer. There are, however, a few short and indistinct setæ on the pleural lobes.

It has often been stated in the literature and accepted by some entomologists that Hemerobiid larvæ are trash carriers (Sharp 95, Fig. 311). No Hemerobiid larvæ studied by the writer have exhibited this habit and in no published accounts of life stages have there been described the well-defined packets characteristic of some species of Chrysopidæ (Smith, 1922, B). The morphology of the larvæ does not suit them to trash or packet carrying. The absence of the long, stout, dorsal and lateral setæ, the short dorsal-hooked setæ, and the lateral tubercles of the characteristic trash carrying Chrysopids would indicate that the Hemerobiids are not trash carriers as the term is commonly used.

The chief point of interest in connection with the legs of the Hemerobiids is that the fairly prominent trumpet-shaped pulvillus (Fig. 2, Pl. V), which is so conspicuous in Chrysopid larvæ is present only in the first instar and may possibly offer a clue for identifying the instar.

The Hemerobiid larvæ have a distinctive manner in walking and running. The head sways or is jerked rapidly from one side to the other as they proceed. The tail is usually held stiffly horizontal, but is brought into use in climbing. There is present a gelatinous anal secretion as in the Chrysopids. The larvæ can run relatively rapid.

The mid intestine is closed behind as in the larvæ of closely related families, and no excrement is voided until the adult stage. Silk is spun from the anus for building the cocoon.

Molting is almost identical with that described for the Chrysopids. Immediately before molting, the cuticula appears dull. The setæ are shrivelled. The head is somewhat distorted, the posterior portion being broader than it was earlier in

the instar. The black eye spots migrate posteriorly and are found near the middle of the side of the head (Fig. 2, Pl. I). A drop of heavy gelatinous fluid from the anus holds the end of the abdomen fast, enabling the stretching movements to take place. The species studied by the writer, and according to Moznette (1916) *Hemerobius pacificus* molt three times in addition to the embryonic molt at hatching, the last molt occurring in the cocoon.

The larvæ were fed plant lice, which they ate readily, but the smaller aphids were found to be preferable for rearing. The following were fed in these rearings: Rosy and green apple aphids and aphids from spiraea, snow-ball, cabbage, elm, and pine. The feeding process was practically identical with that of the Chrysopids. The Hemerobiidæ, however, were more cowardly in attacking aphids than were Chrysopid larvæ. They were frequently frightened away by the slightest movements of plant lice. The larvæ were also cannibalistic, devouring the eggs and larvæ of their own or related species. However, by abundant feeding, as many as ten larvæ of *H. humuli* were reared to adults in the same vial.

The larvæ were taken only a few times in the open, viz., on apple leaves and on spiraea, and by sweeping alfalfa. In collecting, because of their food habits, they would naturally be sought on aphid-infested plants. They are inconspicuous both in color and size, and often hide in curled leaves and leaf or flower clusters.

The identification of the larvæ is difficult. As an aid in classification, the spots on the head, the size and shape of the larva, the coloration, including shade of colors, and the size and arrangement of the spots on the body are of value. The genera are readily recognized, but the species are very difficult to distinguish.

SPINNING THE COCOON.

The larvæ which are full grown after a minimum of eight or ten days, generally seek a somewhat protected place and spin white, rather flimsy cocoons in which to pupate. Some larvæ do not spin cocoons, but curl up (Fig. 7, Pl. VI) and undergo their transformation outside a cocoon. By observing its size, the lobed appearance of the sides, and the somewhat distended abdomen due to the silk secretion, one can usually predict when

a larva will spin. It also ceases feeding for a short time prior to spinning, and can often be readily tumbled about in the vial. The larva first spins a frame-work of small, white, silk threads and occasionally much time and silk is wasted in finding suitable attachments. No general spinning pattern is discernable. The cocoon at the start is much larger than appears necessary to accommodate the prepupa. At first the threads are loose but gradually become taut as threads are attached one to another. The larva generally holds the threads in contact for an instant and appears to press and seal the two together. The threads do not adhere to any part of the body.

After making this outer or foundation cocoon, it begins to spin the inner or cocoon proper. This is much smaller and uniformly oblong in shape. Many of the threads of the cocoons of *H. humuli* and *Micromus posticus* are two or more times the size of other threads. This difference in size of threads is due to the prepupa slowly retracing certain of the threads and depositing an additional layer of silk, an act which may be repeated several times. The meshes are rather large and are three, four, or five sided. The cocoon at best is flimsy and a poor protection. They are occasionally found in the open in curled leaves, or in flower or leaf clusters.

THE PUPA.

The pupa resembles the adult rather closely, though the wings are compressed into small pads. As development proceeds, the body coloration, which suggests in many cases the old larval coloration, appears. The pupa leaves the cocoon after a period of seven to ten days. It does not leave the cocoon through a neat, circular opening as in the Chrysopids, but it bursts the end by tearing the threads and pushing the ends outward, leaving a jagged, irregular opening (Fig. 8, Pl. VI). The pupa immediately seeks to climb up some support to molt. It finds a suitable place, braces itself head always upward, and begins the expansive movements. In a few minutes the abdomen is freed and is shifted forward, causing the cuticula to tear in the mid-dorsal line over the prothorax. The tear extends forward to the bases of the antennæ, and the body is slowly withdrawn. The wings expand in about twelve minutes. In an hour or less it voids the black mass of excrement stored

up during the larval and pupal stages. Two hours after the emergence the coloration of the wings is practically normal.

In rearings, the pupal molt is the most critical stage in the life of Hemerobiids and rather large numbers failed to shed this molt. If no support is found for them to mount and brace themselves for the stretching process they become so weakened after a few hours that they cannot molt, and eventually die. Providing supports for them and a drop or two of water daily during the pupal stage materially reduced the fatalities in rearings.

THE ADULT.

Adults require and accept food as do the Chrysopids. In rearings they were usually fed small aphids, especially the green and rosy apple aphids, which they ate readily by crushing them, sucking up the body fluids and generally devouring the skin also. The palpi hang downward during the eating process and are thus out of the way. The writer observed an adult *H. humuli* devour a young Syrphid larva. Circumstantial evidence, such as exhausted or crushed eggs frequently found in batches deposited by a female over night, supports the view that they may devour or suck the contents from their own eggs. They relish water daily and may be fed for rather long periods on dilute sugar water which they take readily. The adults clean their pulvilli frequently when walking about in a vial. This is accomplished apparently by biting them with the jaws. They void rather frequently brownish or black, sometimes watery excrement containing recognizable parts of aphids.

Some adults of the genus Hemerobius deposited eggs freely in confinement. As a rule, however, they either failed to oviposit or rarely deposited more than thirty or forty eggs. A female of *H. humuli* was observed to deposit 460 eggs, the largest number obtained from one female in these rearings. This individual was captured and this number may, therefore, not represent all that she deposited.

Oviposition was observed many times in these rearings. A very noticeable feature of females ready to oviposit is the large and much distended abdomen. The abdomen may assume a salmon or light amber coloration between the sclerites because of the eggs within. They walk about excitedly, stop suddenly, and bend the abdomen forward, arching it in the middle. The egg

appears quickly at the vulva, micropyle end last, and is deposited flat on the substratum to which it adheres. The time required for this performance is but a few seconds.

The sexes are readily distinguished in the Hemerobiidæ. The males have rather prominent external copulatory appendages which have been figured largely by Banks (1905) and are used in their identification. The female genitalia resemble those of the Chrysopids.

Females begin ovipositing about five days after emergence from the cocoon. A female of *M. posticus* emerged September 29th, 4:50 P. M., was mated the next day, and the first egg was observed October 4th, 12 M. The following day this individual deposited 58 eggs.

Adults can best be collected by beating the limbs of trees and catching the adults as they fly, or by sweeping the branches with an open net and carefully sorting over the contents. Practically all adults taken in these studies were collected in this way.

Among the more striking adaptations that have been noted in this family is the death feigning of the adults. The attitude is distinctly different from that assumed at death, as is the case in most other insects. The head is bent ventrad and the antennæ bent downward and directed posteriorly between the legs along the venter of the thorax, evidently a measure making for the protection of these important appendages. The legs are drawn up stiffly under the body and are quite rigid. The wings remain rooflike at the sides of the body. In this condition the adult may be tumbled about in the vial. On several occasions a start was made to pin individuals before they came out of the feint. A sudden jar, as suddenly picking up a vial containing an adult, or dropping it, may cause it to assume a death feigning position. Sweeping the branches of trees often causes them to drop into the net in a feint. This is not a sign of weakness, for feigning individuals are vigorous when they come out of the feint. The conditions may last for only an instant or may be prolonged. The repellent odor characteristic of many of the Chrysopids was not observed in the Hemerobiids.

It was observed that adults often rest with their head and antennæ upon the substratum as if they were tired of holding them up. Another interesting feature is the ability of the adults to jump in a manner similar to a grasshopper. They jump

rather quickly and may cover several inches. They sometimes leap into the air upon coming out of the feint, reminding one of an Elaterid.

The writer has never observed copulation in any species, and no data have been obtained on hibernation. The adults may be collected very early in the year—as early as February 28th at Manhattan. This would indicate that they overwinter either as prepupæ or adults. Practically no data is available on the number of generations. They have been collected plentifully in April, May, and June, but they have also been taken up to September, leading one to believe that in some species at least there are two or three generations.

LIFE HISTORIES AND DESCRIPTION OF DIFFERENT STAGES OF SOME SPECIES.

The following is a brief description of life histories of a few species which were carefully carried through and upon which the data are fairly complete. Certain incomplete life histories, with the exception of *Lomamyia flavicornis* are not included because it is hoped that more data upon these may be obtained in the near future.

Lomamyia flavicornis Walk. (Family Berothidæ).

Two adults, a male and gravid female, were taken by beating oaks along Wild Cat Creek, June 16, 1920. One infertile egg was deposited which shriveled in a few days.

Egg.—Elongate, elliptical, slightly larger towards the anterior pole, unstalked with white, rather prominent button-like micropyle; gray in color, but with a tinge of yellow and purple or wine color. In certain lights it appears light amber in color and slightly shining. Chorion under high magnification shows a minute but definite hexagonal network of raised reticulations over the entire egg, except the dorsum, so that egg appears rough; hexagons apparently true though some approach circles. Glued to substratum by smooth, shining, gelatinous dorsum. Total length, 0.75 mm., greatest diameter, 0.325 mm.

Hemerobius humuli Linn. (Family Hemerobiidæ).

Plate VI.

This was the most common species encountered by the writer while collecting near Ithaca and Charlottesville. During April, 1919, this species was found in larger numbers in an

apple orchard adjoining the U. S. Entomological Laboratory at Charlottesville than had ever before been noted for any member of the family. The buds were bursting at this time (Fig. 1, Pl. VI) and the young leaves had just appeared. The rosy apple aphids and the green apple aphids were fairly plentiful. A number of gravid females were collected from which rearings were made. At Manhattan this species is quite rare, this probably being near its western limit.

The life history from indoor laboratory rearings of this species may be summarized as follows:

Average period of egg stage (152 eggs), 5.4 days.
Average period of first instar larva (12 larvæ) 2.75 days.
Average period of second instar larva (12 larvæ) 4 days.
Average period from second molt to spinning (11 larvæ), 2.5 days.
Average period from hatching to spinning (34 larvæ), 9.7 days.
Average period from spinning to pupation (8 larvæ), 6.1 days.
Average pupal period (6 pupæ), 9.8 days.
Average period from hatching to emergence of adult (61 life histories, April and September), 25,2 days. Longest period 27 days; shortest, 17 days.

The Egg.—(Fig. 2, Pl. VI). Elongate, elliptical, gray in color except where contents appear cloudy; chorion shining, smooth, with regular rows of minute blunt processes or flat topped elevations slightly irregular in shape and size; processes gelatinous when first deposited; micropyle prominent, pure white, button-like; total length, 0.416 mm., greatest diameter, 0.184 mm.

First Instar Larva (almost two days old).—Head largely translucent, tinged with yellowish gray; eyes black, antennæ stout, annulated, brownish in color; jaws grayish, except tips which are brownish. Dorsal color pattern indistinct, slightly darker at sides with greenish spot in middle. Thorax with gray borders. Dorsal vessel prominent, reddish in color with gray or translucent border. Between this and the gray of the sides is a series of paired brownish red or maroon spots. This series of spots extends back to third abdominal segment inclusive. Segments 4 to 10 faint translucent, yellowish. Lateral border of abdomen gray. Two pairs of single setæ on each segment, except tenth, arising from small pinkish papillæ. Legs hyaline with black rings at end of each femora and proximal border of coxæ; coxæ marked with three slender black rings which converge behind; tibiæ dark, tarsi nearly black. Length, 2.56 mm.; width of metathorax, 0.44 mm.; width of head capsule, 0.26 mm.; length of jaws, 0.24 mm.; length of antennæ, 0.48 mm.

Second Instar Larva (about twelve hours after molt). (Fig. 6, Pl. VI).—Almost identical with the third instar, except in size and depth of color. Head hyaline, smoky longitudinal stripe in median line, uniform in width; jaws, palpi, and antennæ smoky gray, except for amber color of first segment of antennæ and tips of jaws; eyes black, a dark reddish stripe behind each eye to the prothorax. Thorax gray

bordered, a pale brick red to maroon series of spots from prothorax to ninth abdominal segment appearing as a stripe on each side of prominent but almost colorless dorsal vessel; very faint reddish on prothorax, then red, finally dark red, even blackish, due to food in the mid-intestine, on second and third abdominal segments. Dorsal vessel with gray to white borders separating it from the two prominent series of dorso-median red spots. Four pairs of minute lateral setæ on each abdominal segment, the most posterior one the largest. Legs as in previous instar. Length, 4.56 mm.; width of head capsule, 0.4 mm.; width of metathorax, 0.72 mm.

Third Instar Larva (grown, near spinning). (Fig. 5, Pl. VI).—Head yellowish to light amber with a prominent dark mid-dorsal longitudinal stripe; eyes black; a dark reddish black lateral stripe from each eye to prothorax; antennæ and palpi amber but appear dark because of annulations; jaws brownish; palpi about as long as jaws. First subsequent of prothorax half as long as broad, gray to faint yellowish gray, crossed longitudinally by two dark violet or purplish red stripes which appear to be a continuation of those behind the eyes; second subsequent of prothorax grayish with faint yellowish tinge, the two purple stripes continuing over the dorsum but stop at the apodemes. First subsegment of mesothorax one-fourth as long as broad, grayish in center, yellowish tinge on sides, the two purplish stripes much faded; second subsegment gray with yellowish tinge, the two purplish stripes form two triangles with apices at apodemes, behind which the segment is gray. First subsegment of metathorax one-fourth as wide as long, grayish in color, crossed by two dorso-lateral purplish bands; second subsegment like corresponding part of mesothorax. Abdomen and borders of dorsal vessel yellowish gray on sides between which the purplish stripes extend as two series of triangular spots with bases at anterior borders of the segments; spots on segments 1 to 4 distinctly triangular; segments 5 to 8 similar but with apices of triangles broader, forming more distinct stripes; segments 9 and 10 purplish with narrow, yellow border. Dorsal vessel distinct, extending from first subsegment of metathorax to eighth abdominal segment, broadening out about one-third the distance to the border of the next segment. Pleura without tubercles; three to five small inconspicuous single blunt setæ present. Legs as before. Total length, 4.9 to 7.6 mm., width of metathorax, 0.84 to 0.96 mm.; width of head capsule, 0.48 to 0.56 mm.

Cocoon and Pupa (Figs. 8 and 9).—Cocoon normally white, silken, oblong with many of the threads double in size. No distinctive characters were observed in the pupæ.

Hemerobius stigmaterus Fitch. (Plates V and VI).

This species was collected at Ithaca, Charlottesville, and Manhattan, but was never found in large numbers. Rearings were made chiefly from collections made at Manhattan. It was difficult to carry this species through its entire life cycle.

The following is a summary of the life history from indoor rearings:

Average period of egg stage (42) eggs), 5.2 days.
Average period of first instar (12 larvæ), 3.4 days.
Average period of second instar (5 larvæ), 3 days.
Average period from second molt to spinning (6 larvæ), 3.5 days.
Average period from spinning to pupation (4 prepupæ), 7 days.
Average period from pupation to emergence of adult (4 cases), 5.2 days.

The Egg.—Elongate-elliptical, light yellowish or gray with yellowish tinge; micropyle a prominent, raised, button-like structure, white in color; chorion dotted with undulating rows of minute or microscopic elongate, white, raised, rounded spots between which the chorion is smooth; greatest length, 0.53 mm.; greatest diameter, 0.27 mm.

First Instar Larva.—Color almost uniformly gray. Head smoky gray with three large, pale, dark reddish dorsal spots, separated by narrow light gray areas. Body gray, the brownish spots of second instar appearing in latter part of instar. Region of mid-intestine almost black, due to recently ingested food. Legs rather long, hyaline except darker at tips of trochanters, bases of femora and tips of tibiæ; tarsi black with two short claws and a prominent trumpet-shaped pulvillus between them. Total length, 2.53 mm.; width of head, 0.26 mm.; width of metathorax, 0.33 mm.

Second Instar Larva.—Head gray with narrow black bands on each side and a black diamond-shaped bar in mid-dorsal line; eyes black; jaws and antennæ quite dark. Body gray with chestnut brownish markings in form of quadrilateral spots each side of the dorsal vessel on the second subsegments of the thorax, but either absent or indistinct on the first subsegments; a pair of triangular reddish brown spots on the first to eighth abdominal segment; dorsal vessel prominent, black from mesothorax to fourth abdominal segment, lighter beyond. Legs hyaline; femoral joints dark; tarsi black; pulvilli short, not trumpet-shaped. Five pairs of short, inconspicuous setæ dorsally and seven pairs at sides of body. Total length, 3.68 mm.; width of head, 0.34 mm.; width of metathorax, 0.6 mm. Resembles the third instar so closely that it was repeatedly not observed in rearings.

Third Instar Larva.—Same general pattern as the second instar, except colors darker and more distinct. Head, including the jaws, antennæ and palpi very dark, smoky, but with amber tinge; median black bar prominent; eyes black; region behind eyes black; antennæ three segmented and ending in a short seta. Body smoky gray with two broken dorso-median series of dark brownish red, or purplish red in color; on prothorax the spots become elongated stripes; on meso- and metathorax there are two pairs of quadrilateral spots, triangular on the first five abdominal segments and merged into one large spot on the sixth to eighth segment inclusive; the last two segments dark purplish red above. Dorsal vessel conspicuous, with gray border on each side; abdomen gray bordered except for a row of small purplish spots at the extreme outer border; 4 or 5 very short inconspicuous setæ on each side

of each segment; four dorsal pairs of inconspicuous setæ. Legs amber, darkened as in previous instars. Width of head, 0.46 mm.; width of metathorax, 1.26 mm.; total length, 6.5 mm.

Pupa and Cocoon.—Cocoon flimsy, white, silken; no doubled threads observed as in *H. humuli*. No distinctive pupal characters were observed.

Sympherobius amiculus Fitch. Family Sympherobiidae Plate VII.
("The little friend lace wing")

This species was first described from New York. It was taken both at Charlottesville and Manhattan by the writer. Practically all the rearings and life history observations were made at Charlottesville. The writer has also taken *S. barberi* at Manhattan and reared it, but the observations are incomplete. The stages observed closely resemble those described for *S. amiculus*. Because of its very small size and delicacy, this was the most difficult of all species studied to rear. The slightest injury proved fatal. Only adults have been collected in the open and they were rare.

The life history from laboratory rearings may be summarized: Egg stage (46 eggs), 9.15 days; larval stage to spinning cocoon (9 larvæ), 22.2 days; spinning to pupation (7 prepupæ), 4.14 days; pupal stage (8 pupæ), 5.87 days; from oviposition to adult (8 life histories), 40 days.

The Egg (one day after deposition). (Fig. 8, Pl. VII).—Oblong ovate, lower end slightly enlarged, grayish amber in color, later becoming pinkish, shining, regularly reticulated; reticulations minute, oblong, white, raised, round topped spots, somewhat irregular in shape and size, but apparently regular in position; micropyle white, very small, proportionately smaller than in eggs of other species observed; attached to substratum on dorsum total length, 0.29 mm.; greatest diameter, 0.145 mm.

First Instar Larva.—Head smoky, subtranslucent; border behind and in front of eyes black, shading off gradually towards center of head which is unmarked except for faint suggestion of outline of a longitudinal black band in lighter shade; palpi, antennæ, and jaws hyaline, tinged with smoky; tips of jaws slightly tinged with amber; palpi almost as long as antennæ; basal segments of both outlined in black, ending in bristle-like points. Thorax and abdomen distinctly pinkish gray to red; marked at sides with very light grayish pink; sutures red; middle of thorax and anterior part of abdomen light orange, due to food; ninth abdominal segment black; numerous minute short, blunt, lateral and dorsal setæ; a pair of dorso-lateral setæ on each segment with whitish bases. Total length, 1.127 mm.; width of head, 0.184 mm.; length of

jaws, 0.115 mm.; length of antennæ, 0.207 mm.; width of metathorax, 0.207 mm.

Second Instar Larva (one day after molt).—Head largely black; a longitudinal smoky bar in mid-dorsal line, widest in front, tapering abruptly posteriorly to a point, bordered by grayish translucence; eyes black; thorax and abdomen largely without color pattern, except food and visceral color tinges; predominately grayish with a distinct pinkish tinge; fairly prominent and conspicuous grayish lateral lobes present in thorax and abdomen but no lateral tubercles present. In lateral view the prominent lobes are in middle of segment; three grayish spots on lobes of abdomen. Larva unusually short and compact; legs hyaline, very small in size, femora with black rings, tibiæ smoky. Length, 2.81 mm.; width of head, 0.34 mm.; width of metathorax, 0.56 mm.

Third Instar Larva (ready to spin, 18 days old).—Head very dark, marked by a black longitudinal mid-dorsal bar bordered by amber; eyes black; black behind eyes; head appendages dark brownish to black. Thorax mottled gray and light purplish; first subsegment of prothorax less than twice as long as broad with purplish tinge, gray in mid-dorsal region; second subsegment still broader, grayish; apodemes brownish; two dorso-median mottled reddish purple and gray bands begin indistinctly on second subsegment and increase in intensity posteriorly over abdomen; dorsal vessel inconspicuous, appearing as a dark line from mesothorax; sides of body with prominent gray lobes; segments 2 to 4 darker because of excrement in mid-intestine; segments 9 and 10 amber with dark patches above; few small scattered setæ at sides of body, some ending in small knob; last three segments have 3 pairs of setæ each along posterior borders; legs conspicuously small, appear out of proportion to body, smoky gray in color; two claws with inconspicuous pulvillus between. Total length, 4.8 mm.; width of head capsule, 0.46 mm.; width of metathorax, 1.00 mm.

Cocoon and Pupa (Figs. 12 and 13).—Cocoon of reared larva white, flimsy; all threads about the same diameter, none doubled at spinning; cocoon appears larger than necessary; head and tail only slightly flexed; cocoon may be completed in 5 hours. The writer has not studied the pupa.

Micromus posticus Walk (Plate VII).

This species has been taken at Ithaca, Charlottesville, and Manhattan, but it was rare at all places. It was taken by beating trees and sweeping alfalfa. This is slightly larger than the other species discussed. The larvæ are easy to rear and readily identified.

Table II contains a few typical life histories:

TABLE II.

Date Egg Laid	Date Hatched	Spun	Pupated	Emerged
Sept. 7	Sept. 11	Sept. 16	Sept. 21	Sept. 28
Sept. 8	Sept. 12	Sept. 19	Sept. 22	Sept. 28
Sept. 7	Sept. 11	Sept. 16	Sept. 17	Sept. 27
Sept. 11	Sept. 15	Sept. 23	Sept. 27	Oct. 12

The Egg (Fig. 5).—Distinctly pink in color, often a salmon pink, varying in intensity with stage of development; shining, iridescent or with an oily sheen; elongate ovate; micropyle white; without reticulations of any kind; usually glued fast on dorsum; length, 0.66 mm.; largest diameter, 0.40 mm.

First Instar Larva (one day old).—Head hyaline, slightly smoky; antennæ, jaws, and palpi hyaline, slightly smoky; tips of jaws amber; eyes jet black, a brownish band extending posteriorly from each; faint outline of median bar outlined in smoky gray in mid-dorsal region; two large smoky areas each side from antennæ to prothorax, making the head appear three spotted, the spots separated by clear spaces. First subsegment of prothorax entirely hyaline, but with reddish tinge; second subsegment dark red or maroon in middle, lateral lobes hyaline with two small setæ on each. Mesothorax and metathorax similar; central area dark red, lateral lobes smoky gray. First four segments of abdomen entirely dark red; remaining segments hyaline with reddish or pinkish tinge in the center; two minute setæ at the sides of the lobes and prominent dorsal ones on last four or five segments of the abdomen. Legs hyaline; femoral joints black; tibiæ smoky proximally; tarsi with very small trumpet-shaped pulvilli. Total length, 3.3 mm.; width of head, 0.23 mm.; width of meta-thorax, 0.45 mm.

Second Instar Larva.—Differs from the other instars, especially the third, chiefly in size. The color is some shade of red, often with a purplish tinge. Three pairs of prominent white spots on the sides of the thorax surrounding the very small lateral tubercles. Dorsal vessel red to purplish with gray border. Total length, 4.6 mm.; width of metathorax, 0.66 mm.; width of head, 0.33 mm.

Third Instar Larva (rather early in stage).—Head very dark, with three dorsal smoky patches, at sides and in middle; antennæ, jaws, and palpi blackish brown; antennæ two segmented without long apical seta; eyes black. First subsegment of prothorax about twice as long as broad, a dark purplish red tinge, lighter at sides; second subsegment also long; apodemes brownish, a pair of white spots either side in which there is a small tubercle bearing three short setæ each; three rows of short setæ across segment; median area tinged a very dark red. First subsegment of mesothorax short, dark purplish except for white mid-dorsal region; second subsegment largely gray in color; lateral tubercles very small, gray, bearing two setæ each; dorsal vessel very dark purple with a prominent gray border on both sides; dorso-lateral area dark

purplish red. First subsegment of metathorax narrow, dark purple, except gray border of vessel; three pairs of short, black setæ in a row. Second subsegment largely gray, with two very small lateral gray tubercles bearing five setæ each; prominent gray border on both sides of vessel which is dark red. Abdomen dark red to purplish, with lighter shade at sides and with gray borders on both sides of dorsal vessel. End segments dark purple. Each abdominal segment with two rows of eight small dark setæ each. Legs dark; coxæ black; distal ends of femora, proximal ends of tibiæ, and whole of tarsi black. Total length, 6.8 mm.; width of head, 0.48 mm.; width of metathorax, 1.04 mm.

Cocoon and Pupæ (Figs 6 and 7).—Cocoons were found in curled apple leaves. Reared larvæ normally spin white, oval cocoon with some threads doubled in size. The prepupæ retain largely the larval color pattern, which is usually some shade of red with three pairs of prominent white spots at the sides of the thorax.

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EXPLANATION OF PLATES.

Plate V.

Hemerobius stigmaterus Fitch (except Fig. 4).
Drawings by S. Fred Prince.

Fig. 1. Grown third instar larva, about 10 times natural size.
Fig. 2. First instar larva, ready to molt. × about 15. Note that the eyes have receded from their normal position and that the head capsule is slightly expanded posteriorly.
Fig. 3. Egg burster of this species. × about 160.
Fig. 4. Egg burster of *H. humuli*. × about 160.
Fig. 5. Egg of *H. stigmaterus*. × about 35.
Fig. 6. A prepupa in its cocoon. × about 10.
Fig. 7. An adult female with wings expanded. × about 6.

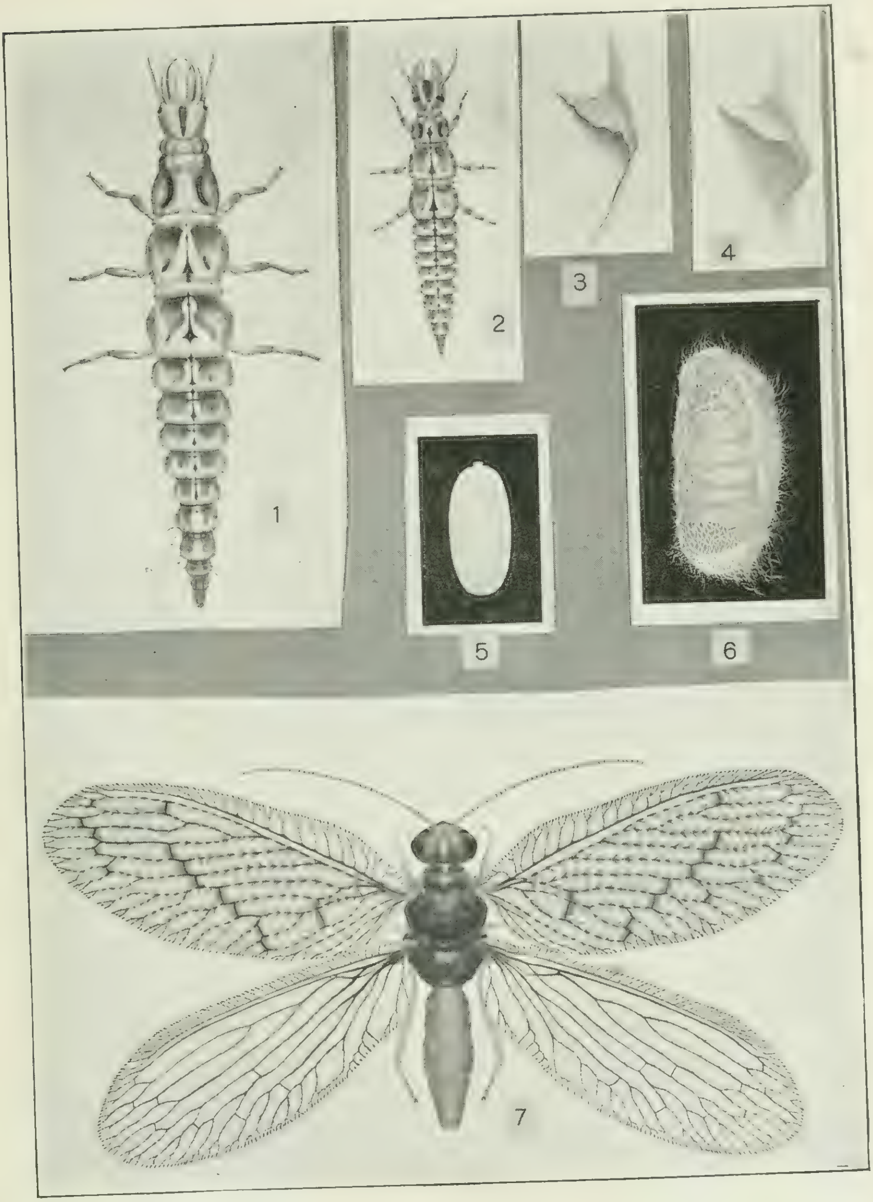
Plate VI.

Fig. 1. Adult of *Hemerobius humuli* Linn. on apple bud, enlarged about 1½ times.
Fig. 2. Egg of *H. humuli* soon after deposition. × about 70.
Fig. 3. Egg of *H. humuli* just before hatching. × about 70. Note the prominent eye spots at upper end and abdomen of embryo in lower portion of egg directed upward. The cotton fiber is adhering to the venter of the egg showing its gelatinous nature.
Fig. 4. Egg of *H. humuli* on sepals of an apple bud as deposited in the open. enlarged about 15 times.
Fig. 5. Grown third instar larva of *H. humuli* on apple leaf. × about 5.
Fig. 6. A second instar larva of *H. humuli*. X about 5.
Fig. 7. A prepupa of *H. humuli* which failed to spin a cocoon and is developing outside a cocoon in nearly normal position. × about 15.
Fig. 8. A pupa of *H. humuli* leaving its cocoon. × about 20. Note that the threads have been torn and pushed outward.
Fig. 9. A typical nearly mature pupa of *H. humuli*. × 13.
Fig. 10. A newly deposited egg of *Hemerobius stigmaterus* Fitch. × about 70.
Fig. 11. An early reared third instar larva of *H. stigmaterus*. × about 5.
Fig. 12. A larva presumably of *H. stigmaterus* collected in West Virginia by F. W. Poos. × about 6.

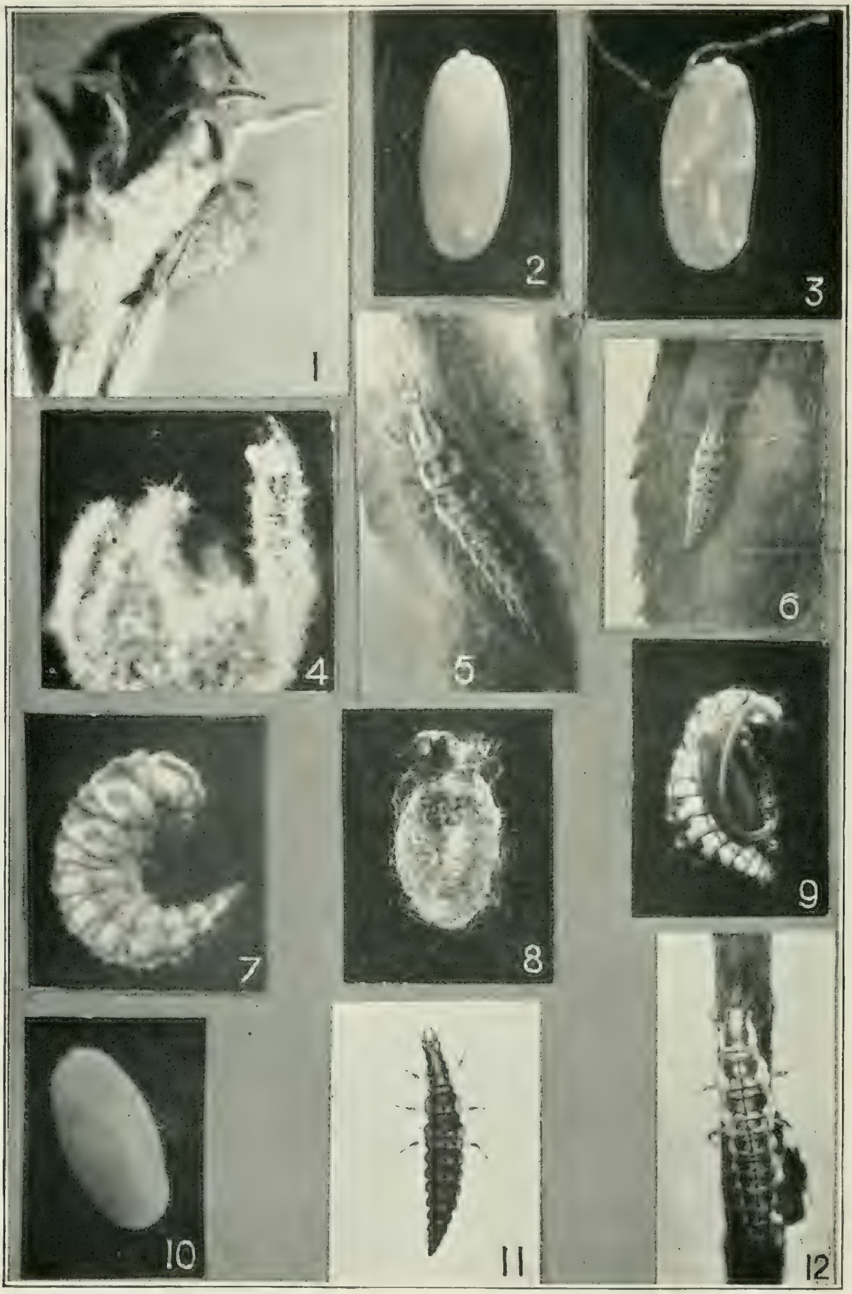
Plate VII.

Fig. 1. Adult of *Micromus posticus*. × 3. Legs and antennæ arranged as in death.
Fig. 2. Grown larva of *M. posticus* showing color markings. × about 6.
Fig. 3. Another grown third instar larva of *M. posticus*, but showing less white on dorsum. × 6.
Fig. 4. Eggs of *M. posticus* on maple leaf as deposited in the laboratory, Ithaca, N. Y., about natural size.
Fig. 5. Egg of *M. posticus*. × 15.
Fig. 6. An early prepupa of *M. posticus* in cocoon. × about 5.
Fig. 7. An early reared pupa of *M. posticus* in its cocoon. × about 6.
Fig. 8. Newly deposited egg of *Sympherobius amiculus* Fitch. × about 70.
Fig. 9. A second instar larva of *S. amiculus* on apple leaf. × about 10.
Fig. 10. A nearly grown third instar larva of *S. amiculus*. × 7. Killed before photographing.
Fig. 11. A grown third instar larva of *S. amiculus* photographed alive on an apple leaf. × 5.
Fig. 12. A prepupa of *S. amiculus* in its cocoon. × about 5.
Fig. 13. A nearly mature pupa of *S. amiculus*. × 13.

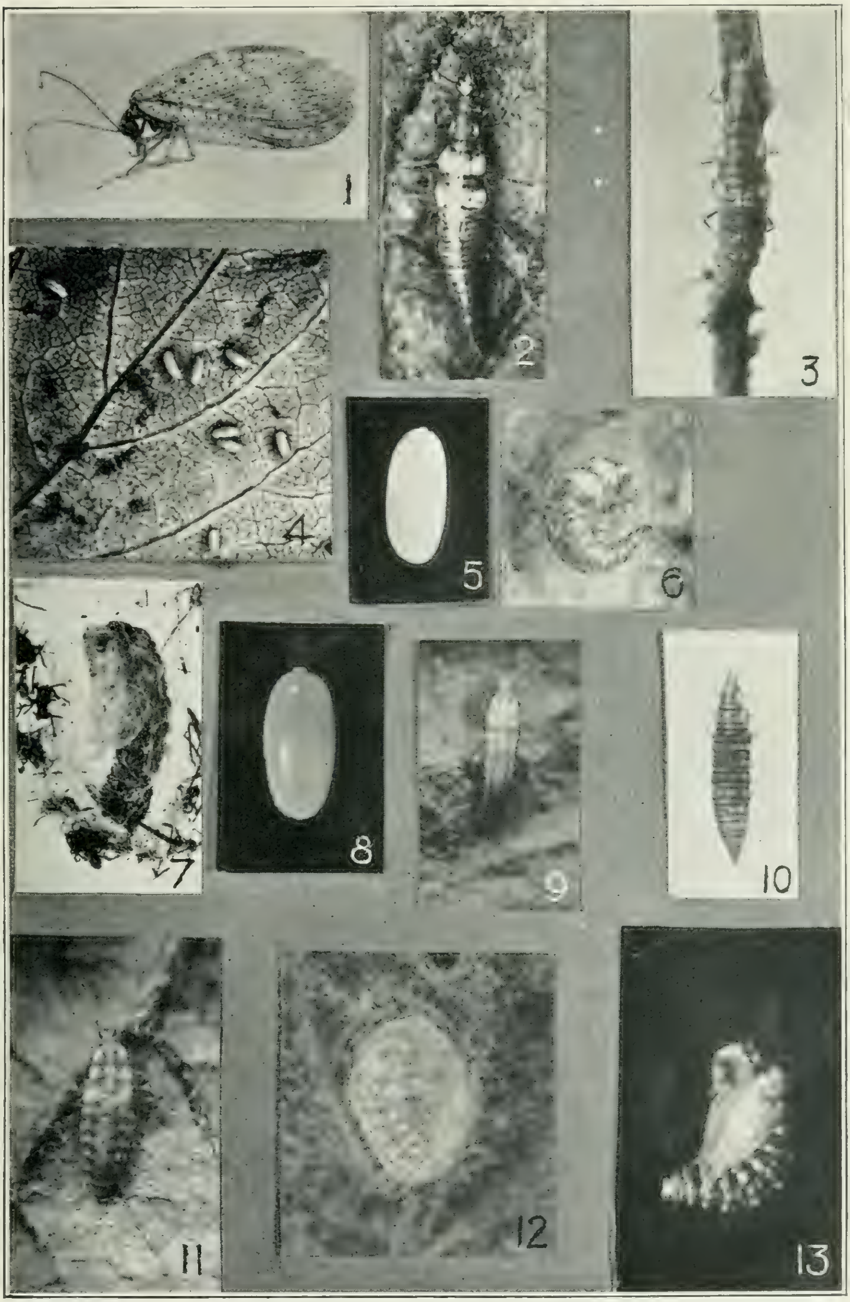
(All photographs by the author.)



Roger C. Smith.



Roger C. Smith



Roger C. Smith.

NOTES ON THE LIFE HISTORY OF CLASTOPTERA OBTUSA AND LEPYRONIA QUADRANGULARIS*

(Order Hemiptera, Family Cercopidae).

PHILIP GARMAN.

The following notes relate to the habits and life history of two cercopids or spittle bugs and constitute records on the length of the different stages at New Haven as well as descriptions of some of the early stages. The first of these bugs (*Clastoptera obtusa* Say) feeds on alder,† while the second (*Lepyronia quadrangularis* Say) feeds upon golden rod and other weeds.

THE ALDER SPITTLE BUG.

Clastoptera obtusa Say.

This species is very common in Connecticut and the white masses of spittle may be seen on nearly every twig of some bushes. The eggs of the first or spring brood are laid in the fall, during September and October, hatch in May (May 10–22, 1922) and the nymphs remain on the twigs from 29–42 days, depending on the temperature. Adults may be found beginning the middle of June and become mature early in July, laying eggs until the latter part of this month. Judging from what happens in the case of the grass-feeding species (*Philænus lineatus*) which begins to lay about the same time, the eggs should remain until the following spring without hatching, but they do not. Nearly 90 eggs obtained in captivity hatched in from 12—21 days, the outdoor average for this time of year being 16.5 days. The second brood nymphs give forth adults from the middle of August to cold weather or in this locality to the last of September and begin to lay eggs about the middle of this month. Field observations have verified the above facts, it being noted at New Haven that there is a considerable interval between first and second generation when few or no nymphs can be found. This interval occurs between the middle of June

* Contribution from the Connecticut Agricultural Experiment Station, 1922.
† *Alnus rugosa* (Du Roc) Spreng. (Smooth alder).

and the middle of July. Freshly emerged adults are numerous shortly after the middle of June and the middle of August and few are found between these dates. Eggs become numerous on new growth after the first of July. Adults reared in confinement from nymphs of the spring generation emerged June 21 and laid eggs in July which hatched after the usual interval for the second brood.

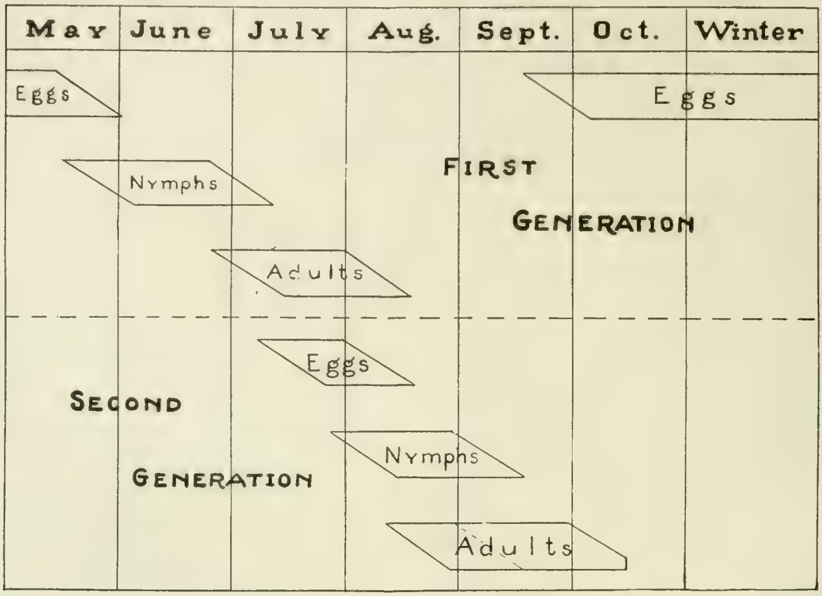


Diagram showing life history of Clastoptera obtusa. Stippled area shows probable overlapping of first and second generation adults.

The cause for the early hatching of the eggs laid in July as contrasted with that of the grass-feeding species which remains until the following spring is not well understood, but it may be explained as suggested by Dr. A. C. Baker, by the fact that the species is of southern origin while *P. lineatus* is a distinctly northern species. Another reason for this two brooded condition lies in the fact that alders provide a continual supply of fresh green food throughout the summer and well into the fall so that the younger stages of the spittle bug can continue feeding without interruption nearly until frost. On the other hand the redtop and timothy grasses grow most rapidly in spring and there is less chance for continual feeding in the case of the

grassfeeding species. However, it must be remembered that there are often varietal and specific differences in habit which cannot be accounted for by known differences in environment.

The egg (Fig. 1) is laid just underneath the bark usually in a diagonal position similar to that of other cercopids. The opening in the bark is then covered with a tough adhesive substance for protection. Winter eggs are frequently laid just above and behind a bud, which grows and protects them as seen in Fig. 7. The summer eggs are laid in almost any position on the new growth, though usually in a diagonal position.

A week or so before hatching, the egg-covering splits and the egg is seen protruding. When first laid it is nearly white and if the covering is removed in mid winter, the egg will be found with only a slight yellow tint. When the covering splits the exposed portions turn black.

THE NYMPH.

There are probably five nymphal instars though in a great many cases only four moults have been found in reared examples. The first two instars are similar in many details. They are orange in color with darker conspicuous spots on the sides of the abdomen. The antennae consist of two segments and the eyes of from six to nine divisions. The third instar turns grayish in color especially the abdomen, while the antennæ increase in length and number of segments. As yet there is little development of the wings. The fourth instar shows conspicuous wing development but the thorax is usually much narrower than the abdomen. The fifth instar shows still further wing development, the latter being now curved and extending on to the ventral surface in freshly collected specimens. The thorax also widens perceptibly in this stage and the structures of the adult thorax soon become visible through the cuticle. In all stages the antennæ are folded beneath the head and are invisible from above, the species differing in this respect from most other cercopidæ. There is also considerable variation in color pattern, and some specimens are much darker than others.

DESCRIPTION OF THE DIFFERENT STAGES.

(Plate, VIII)

Egg.—(Fig. 1). Size .3 by .8 mm., long ovate, white or slightly yellowish, becoming black on exposure to the air before hatching.

First Nymphal Stage.—(Fig. 2). Length .8–.9 mm. Compound eye with about 10 divisions, antennæ inconspicuous, with two divisions. Head and thorax infuscated including the legs; wings not visible. Abdomen pale yellow, with a large orange spot (spittle gland) on each side, tip of abdomen infuscated.

Second Nymphal Stage.—(Fig. 3). Length 1.2–1.7 mm. Head and thorax infuscated, including the legs; eyes with 10–12 divisions, antennæ with three segments. Wing-pads not visible. Abdomen yellow at first, turning pale later, spittle glands conspicuous.

Third Nymphal Stage.—(Fig. 4). Length 2–2.5 mm. Head brown, antennæ consisting of three segments, the proximal one being dark, distal segment much longer than the rest; eyes with numerous facets. Thorax and legs brown, the wings slightly developed as lateral extensions of the margins of the thorax. Abdomen gray, the orange glands at the sides still conspicuous.

Fourth Nymphal Stage.—(Fig. 8). Length 2.5–3 mm. Head brown below, mottled above near caudal margin; antennæ consisting of three or four well defined proximal segments and a number of indistinct distal segments, the distal portion irregularly marked with dark rings. Thorax mottled above, the legs fuscous. Abdomen gray, the spittle glands less conspicuous than in the third stage, tip of abdomen dark.

Fifth Nymphal Stage.—(Fig. 9). Length 3–5 mm., greatest width 2–2.5 mm. Color green or yellowish. Head and thorax green or cream colored, mottled with brown. Antennæ black preceded by a pale ring on the head, segments 3 and 4 each with pale rings; legs and rostrum brown, the legs with tips of tibiæ and tarsi darker. Wing pads well developed, dark, and extending well onto the venter of the thorax. Abdomen frequently with dark patches caudad of the wing pads.

Adult Male.—(Pl. IX Fig. 5). Dorsal aspect most commonly as in Fig. 5. Head with 7–8 interrupted brown lines between the antennæ, the face behind these lines below nearly black; rostrum dark brown.

Thorax: Pronotum rugose, the caudal half and cephalic margin usually brown, and a narrow brown stripe as in Fig. 5 connecting the lateral angles. Scutellum brown, margins and apex usually paler. Femora dark brown to black, tips paler; tibiæ and tarsi brown, those of the hind legs much paler than the front and middle coxæ and lateral thoracic sclerites of meso and metathorax nearly black; venter of metathorax light brown; elytra as in Fig. 5, usually dark brown with irregular white line from scutellum to costal margin; apices also pale, with a dark spot on costal margin; elytra finely pubescent with pale hairs.

Abdomen: Abdominal segments dark brown below with pale caudal margins.

Female.—Length 4–5.5 mm., usually lighter in color than the male, especially the ventral surface of the abdomen.

Variations. Two varieties of this species have been found in Connecticut; var. *achatina* Germar and *testacea* Fitch. The variety

achatina was reared from hickory at New Haven and differs from the variety *obtusa* in having the pronotum entirely brown and the elytra without the pale transverse mark at middle. The variety *testacea* was collected at Rainbow, Connecticut, and is uniformly brown except for the stigmal spot on the costal margin of the elytra and dark areas behind the mesocoxæ. It differs from the variety *achatina* in having the face entirely brown below. The life history notes here presented refer only to *C. obtusa* variety *obtusa*.

HABITS OF THE NYMPH.

The nymph does not make many changes in its position after once establishing itself. At about the time of the third molt it may migrate a considerable distance from its first position but this is the only time that it shows signs of restlessness. For the most part the nymph remains at one point feeding and molting within the spittle. However, the adult is not formed within as with the grass-feeding frog-hopper, but the nymph leaves the mass and wanders about until it finds a suitable place to transform.

HABITS OF THE ADULT.

The adult like most other cercopids is sluggish, easily captured and when disturbed flies only a short distance. It feeds upon the tender shoots of the host plant and apparently does not leave the latter being usually found upon it or very close to it.

The females of the first brood become mature in about two weeks after emerging. The second brood apparently requires a longer time, three to four weeks, and mating occurs in the case of the second brood about ten days after coming from the spittle. The total number of eggs obtained from a single female of the second brood varied from 22 to 35, according to cage records and the majority live only about a month after emerging from the spittle. The eggs of the second brood are laid usually between September 15 and October 1. A single fairly complete record illustrates the course of the life history of the second brood at New Haven. Eggs were obtained July 1 from adults confined in a wire cage. One of these hatched July 19 and three molts were seen up until August 20 when an adult female emerged. An adult male was introduced August 21 and died September 1. Mating was not observed in this cage but was observed in other cages from August 26 to September 1. The

female began to lay September 14 and lived until October 3, when 35 eggs were counted on the twigs of alder upon which the bug was confined.

HOST PLANTS.

Clastoptera obtusa has been reared from gray birch, white birch, witch hazel and hickory. As already noted the form on hickory is much different from the form on alder and corresponds to the description of the variety *achatina*.

ENEMIES.

The egg is apparently too well protected to be parasitized; at least none have been observed with parasites. The nymph, however, is attacked by the larva of a small fly *Drosophila inversa* Walker* which appears the latter part of July and the first of August and which is particularly well adapted to its life beneath the spittle. The larva (Pl.VIII Fig. 6) of this fly has a long anal tube which it thrusts through the spittle to take air, in this way avoiding suffocation. Still more unexpected is the provision of the pupa (Pl.VIII, Fig. 5) with similar tubes extending from the anterior end. Being inactive, some provision is necessary to keep the tubes above the spittle so they are provided with four radiating hairs apparently to support them in the surface film.

No great harm to the bugs results from the presence of the fly larvæ and they are able to mature and emerge as adults without difficulty. The larvæ no doubt obtain some nourishment direct from the spittle as suggested by Baerg and do not draw much from the body of the nymph itself.

During August the nymphs were also found to be attacked by the Pentatomid *Podisus maculiventris* (Say). One individual was noted which had speared an almost mature nymph and could hardly be induced to give up its prey. The Podisi were seen in considerable numbers at this time and no doubt destroy many spittle bugs.

* This insect has been described by Baerg, Ent. News, XXXI; 20–21; 1920, and Ainslie, Can. Ent., 38: 44: 1905. The adult fly was determined by Dr. C. W. Johnson.

TABLES GIVING LIFE HISTORY DATA OF THE ALDER SPITTLE BUG, 1922.

EGG: SECOND BROOD.

Date Laid	Date Hatched	*Length of Incubation—Days* 12	13	14	15	16	17	18	19	20	21	Mean Temp. F.
June 30	July 16						1					69.7
June 30	July 17							4				70.0
July 1	July 18						12					70.1
July 1	July 21									1		70.1
July 1	July 22										1	70.3
July 1	July 18						10					70.1
July 1	July 19							6				70.7
July 7	July 22				7							72.8
July 7	July 23					11						72.9
July 7	July 24						8					72.7
July 7	July 25							4				72.4
July 8	July 23				2							73.0
July 8	July 24					13						72.9
July 11	July 27					4						70.1
July 14	July 31						2					70.2
July 9	July 21	4										80.6–89.6*

* Incubator temperature.

Date Hatched	Date Emerged	*Length of Nymphal Stages—Days* 22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	Mean Temp. F.
April 23	June 4																					1	61.7
May 10	June 16																1						63.6
May 14	June 20															1							64.3
May 14	June 21																1						64.3
July 17	Aug. 20													1									70.6
July 18	Aug. 18										1												70.4
July 18	Aug. 17									1													70.3
July 19	Aug. 20											2											70.3
July 19	Aug. 17								1														70.2
July 22	Aug. 20								1														70.6
July 17	Aug. 8	1																					80–89.6

The Quadrangular Spittle Bug.

Lepyronia quadrangularis Say.

Only a few notes on this species will be given here.

Its life history differs from the grass-feeding and the alder bug in the fact that the adult bug passes the winter. Attempts to secure eggs in captivity from adults collected in the field failed entirely during the fall of 1921 and 1922 and it was only late in the season (September 27) that mating was observed in confined specimens. No eggs were obtained in the fall in small breeding cages, though in one field cage, eggs were apparently laid, which passed the winter and hatched the following spring. However, eggs were obtained easily in the spring of 1922 from adult females collected in low and swampy areas.

Adults migrate to swamp land to pass the winter and abandon the high ground where few can be found during the late fall and winter.

The egg is laid quite differently from other cercopids studied, being pushed directly into rotten and decayed stems of golden rod or other weeds—not in fresh tissue. The opening is closed and almost completely hidden by the usual adhesive substance employed by spittle bugs. Fig. 4 shows the eggs as they appear in a cut stem of golden rod.

In general then it may be stated that the quadrangular bug spends the greater part of its life as an adult insect, laying eggs very late in the fall if at all, but mostly in spring, the first or middle of May. The eggs hatch in about one month and the nymphal period probably consumes a month longer. This brings us to the middle of July at New Haven when adults begin to emerge from the spittle. From then to the egg-laying period, the preoviposition period, consumes two months and in the case of the eggs laid in the spring nine or ten months.

DESCRIPTION OF THE EGG.

(Plate IX, Fig. 4.)

Almost white, when fresh, cream colored when older; elongate and shiny. Total length 1 mm., width .35 mm.

EXPLANATION OF PLATES.

Plate VIII.

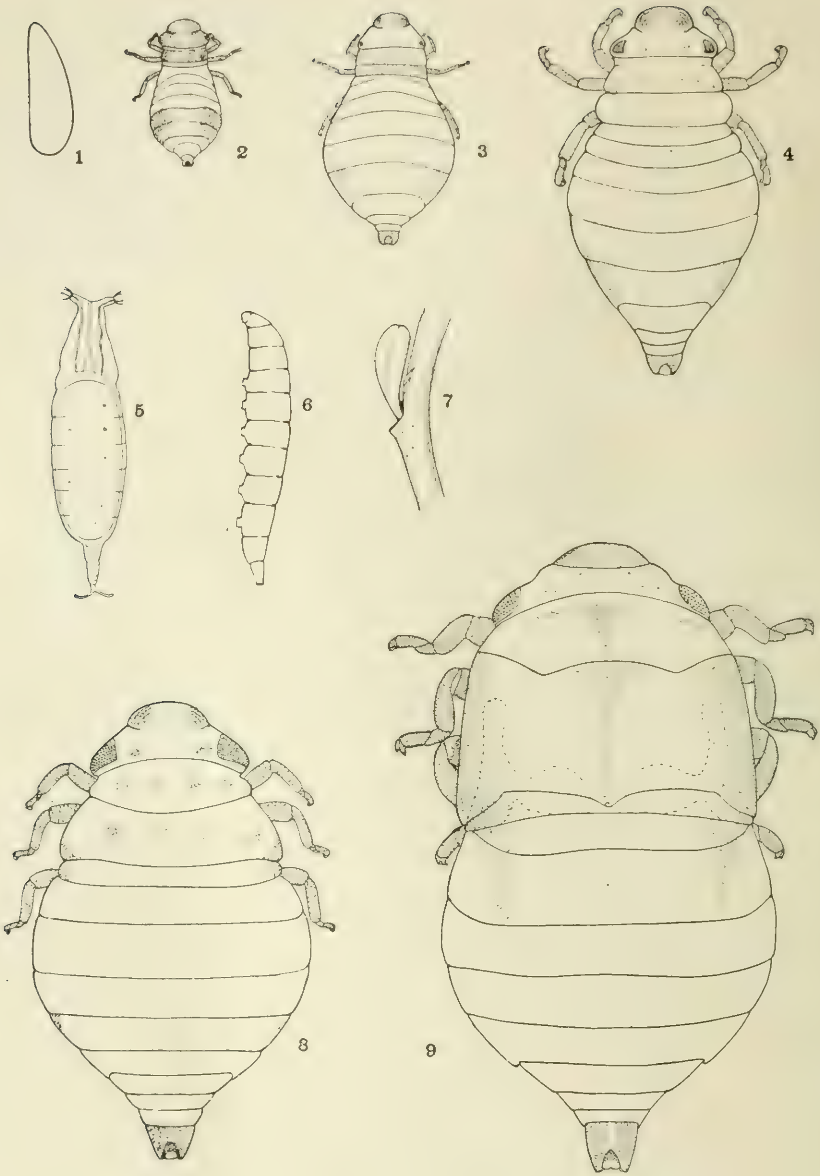
Clastoptera obtusa and *Drosophila inversa.*

1. Egg. 2. First nymphal stage. 3. Second nymphal stage. 4. Third nymphal stage. 5. Pupa of *Drosophila inversa.* 6. Larva of *Drosophila inversa.* 7. Winter eggs. 8. Fourth nymphal stage. 9. Fifth nymphal stage.

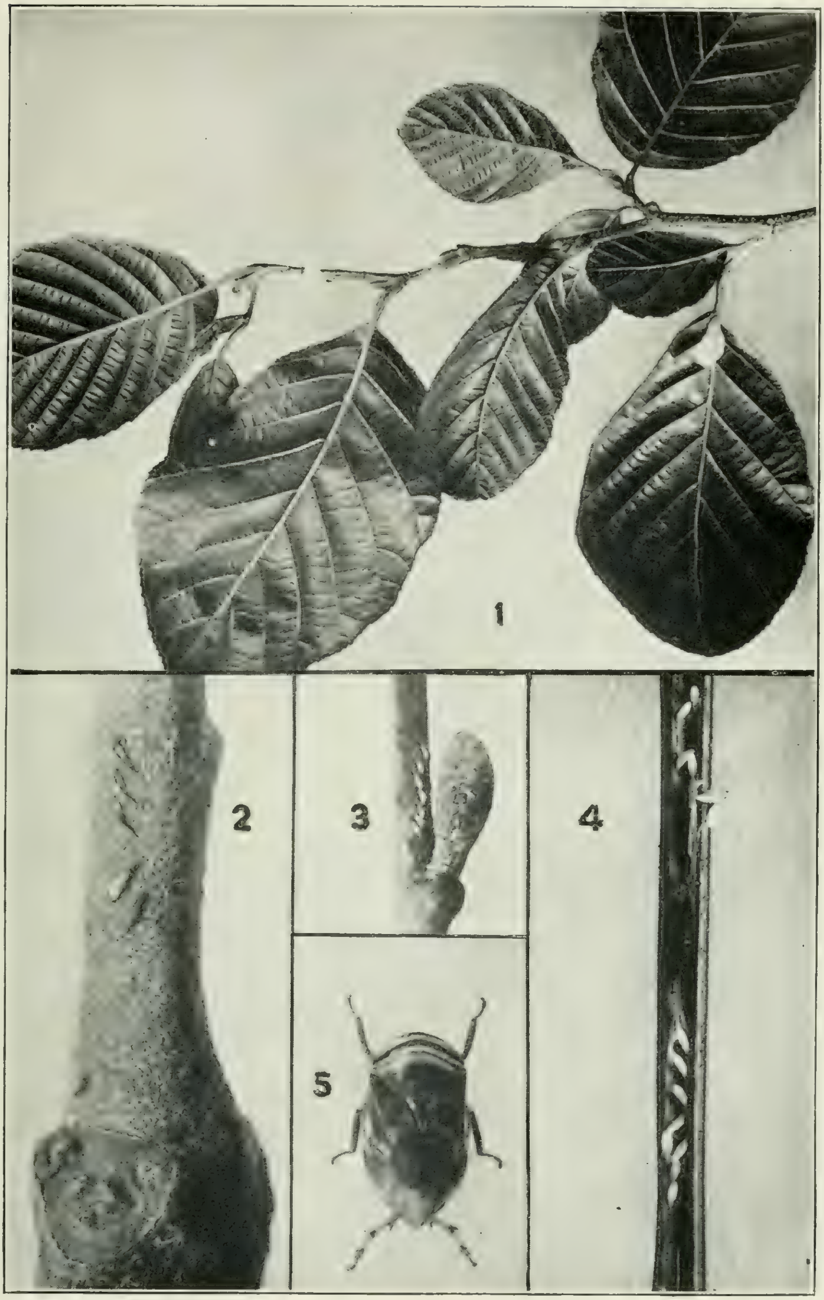
Plate IX.

Lepyronia quadrangularis Say and *Clastoptera obtusa* Say.

1. Spittle masses on alder. 2. Summer eggs, greatly enlarged. 3. Winter eggs, of Clastoptera obtusa Say. 4. Eggs of *Lepyronia quadrangularis* Say. 5. Adult male of *Clastoptera obtusa* Say.



Philip Garman.



Philip Garman.

A REVIEW OF THE NORTH AMERICAN COREINI (HETEROPTERA)

S. B. Fracker,
Madison, Wisconsin.

The great uniformity within the tribe Coreini has resulted in some confusion in regard to the different species. As is usual in the Heteroptera, individual variation makes the differentiation of species difficult.

The subfamily Coreinae of which this tribe is a member is distinguished from other groups of the family largely by negative characteristics. The structural peculiarities of membrane venation found in the Pseudophloeinae, the unusual position or obsolescence of the scent gland orifices of the Corizinae, the large head and narrow thorax of the Alydinae, and the toothed tibiae and swollen femora of the Merocorinae are all wanting in the Coreinae.

As is usual in what may be called residual groups of this kind, considerable structural variation occurs within the subfamily.

A similar statement may be made in regard to the *tribe* under discussion. It contains those members of the subfamily Coreinae which are not distinguished by peculiar expansions or shapes of the tibiae or antennae, by prominently armed femora, nor by unusually widely separated posterior coxae.

Stal in his synopsis of the Coreini uses the relative length of the bucculae as the principal character for dividing the tribe. The immediate cause of writing the present paper* was the difficulty of using this character in practice and the confusion resulting from individual variations in such a structure among very closely related genera. In the following synopsis of the genera an attempt is made to eliminate this difficulty. Only the species found north of Mexico have been considered.

* The collections examined in the preparation of this paper were those described in the author's "Alydinæ of the United States," with the addition of those of Cornell University, the Field Museum of Chicago, the American Museum of Natural History at New York; Mr. H. G. Barber, Roselle, New Jersey; Prof. Herbert Osborn, Columbus, Ohio; Prof. C. J. Drake, Ames, Iowa; and part of the collection of the Illinois State Laboratory of Natural History. The author is indebted to those in charge of these collections for the privilege of examining them.

SYNOPSIS OF THE GENERA.

a. Femora, at least the posterior, armed with one or more spines; membrane with veins simple or slightly branching; rostrum attaining or surpassing intermediate coxæ.
 b. Pronotum with lateral angles spinose............................*Zicca.*
 bb. Pronotum with lateral angles rounded or angular, not spinose.
  c. Juga not prominent, not extending beyond tylus; head very short, less than half as long as pronotum.
   d. Head nearly one-half as wide as pronotum; antennæ usually with first segment longer than second; body elongate.................*Namacus.*
   dd. Head elongate, not over one-third width of pronotum; antennæ with first segment shorter than or equalling second; body stout. *Anasa* (in part).
  cc. Juga prominent, acute above tylus; head nearly as long as pronotum; body very broad......................................*Chelinidea.*
aa. Femora all unarmed.
 b. Membrane with irregular and anastomosing venation.
  c. Antennæ longer than body; posterior coxæ widely separated.....*Madura.*
  cc. Antennæ shorter than body.
   d. Tylus forming a prominent keel between antennæ, articulation of antennæ on apex of antenniferous tubercles, not guarded by dorsal and ventral plates..*Margus.*
   dd. Tylus low and rounded, not forming a prominent keel; articulation of antennæ guarded above and below by expanded plates..*Scolopocerus.*
 bb. Membrane with simple or slightly branching venation.
  c. Rostrum short, scarcely surpassing anterior coxæ, first segment not extending behind eyes......................................*Cimolus.*
  cc. Rostrum longer, attaining or surpassing intermediate coxæ, first segment surpassing posterior margin of eyes.
   d. Posterior coxæ widely separated; body stout.
    e. Articulation of antennæ laterocephalic, not guarded beneath by an expanded plate of the genæ; scent gland orifices with a round button-like prominence at the anterior margin; size large..*Anasa* (in part).
    ee. Articulation of antennæ cephalic, guarded beneath by an expanded plate of the genæ; scent-gland orifices without button-like prominence; size not over 13 x 4 mm....................*Catorhintha.**
   dd. Posterior coxæ nearly contiguous; body elongate, compressed. *Hypselonotus.*

Madura.

Madura is a South and Central American genus, of which one species, *M. perfida* Stal, has been found in Texas. The antennae are about as long as the body, the elongate first segment thickened at the tip; the rostrum reaches the posterior coxae; the wing veins are partially anastomosing. The species is small, measuring only 6.5 by 1.5 mm.

Chelinidea.

Owing to the peculiarities of Chelinidea, Stal in his synopsis of the Coreidae did not attempt to include it in any tribe but separated it from all other genera. The superficial resemblance

* Including Ficana.

to Pentatomidae is marked. Two species, similar in appearance and tending to intergrade in the southwestern states, have been described.

McAtee* has recently revised the genus, the two species of which had formerly been separated on color characters. This author limits *C. tabulata* Burmeister to the forms with the humeral angles elevated and the anterior pronotal angles prolonged into spines directed cephalad. The head and legs are flavous marked in part with a rich buff. The distribution includes Texas and Mexico.

C. vittiger Uhler, with the humeral angles lower than the remainder of the thorax, and the anterior pronotal angles either obsolescent, or short and directed outwardly, is divided into subspecies *vittiger* Uhler and *aequoris* McAtee. In the former, which typically has the head and legs black, the anterior part of the pronotal margin is distinctly carinate and bears an outwardly directed tubercle; both of which characters are reduced to obolescence in the pale subspecies *aequoris*. A pale color variety of *vittiger* is given the designation *artuflava* McAtee, and a dark variety of *aequoris* is called *artuatra* McAtee.

Subspecies *vittiger* is distributed throughout the Rocky Mountain States, while *aequoris* is known from Virginia to Texas. All members of the genus breed on cactus (Opuntia and Cereus).

Margus.

M. inconspicuous Herrich-Schaeffer, widely distributed in the southwestern states, and *M. obscurator* Fabricius (from Florida) are the North American representatives of this large tropical genus. The former (11 mm. long) is much larger than the latter and possesses blunt, rounded antenniferous tubercles, those of *M. obscurator* being acutely produced externally at the apex.

Namacus.

The large size (14 mm. length) and bright red and black coloration of *N. annulicornis* Stal make it a conspicuous insect. The distribution is subtropical.

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* McAtee, W. L. Notes on Nearctic Heteroptera. Coreidæ. Bul. Brooklyn Ent. Soc. 14, 1919, 9–13.

Scolopocerus.

The species of Scolopocerus, all of which come from the southwestern states, have been discussed by Barber.* His synopsis includes a misprint concerning *S. granulosus* Barber in the phrase "pronotum much wider than long" which should read "longer than wide." The statement is correctly given in the description (p. 166) and the discussion (p. 167). In this species and in *S. secundarius* Uhler the first segment of the antennae is longer than the second and the hemelytra do not reach the apex of the abdomen. *S. uhleri* Distant possesses a short first antennal segment, and long hemelytra. The pyriform swollen fourth antennal segment and the slender pronotum distinguish *granulosus* from the others. A short-winged form of the latter species is at hand.

Catorhintha.

The species of Catorhintha, Ficana, and Anasa, bear a very close resemblance to each other and are difficult to group. In addition to the small size, the presence of a small, horizontal, shelf-like plate beneath each antenniferous tubercle, which does not seem to have been described heretofore, is a constant feature which distinguishes the first two genera named from Anasa. This plate is a lateral expansion of the gena and appears to form a ventral guard for the articulation of the antenna. The shape of the margins of the gland orifices is mentioned in the synopsis of the genera.

The writer is unable to find any adequate basis for giving generic rank to "*Ficana apicalis* Dallas" although the bucculae are possibly a trifle shorter than and the rostrum longer than in the species of Catorhintha. If Ficana is considered a subgenus, the species group themselves in such a way that at least one and possibly two new subgenera should be erected, but it is believed this change would serve no useful purpose. *F. apicalis* is consequently being placed in Catorhintha, a position which would be scarcely disputed by Stal judging from his brief statement in 1870.†

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* Barber, H. G. New Hemiptera-Heteroptera. Jour. N. Y. Ent. Soc. 22, 1914, 166.

† Stal, C. Enumeratio Hemipterorum 1, 1870, 188. "Hoc genus Catorhinthæ est maxime affine."

SYNOPSIS OF THE SPECIES OF CATORHINTHA.

a. Antenniferous tubercles acute externally at apex, often produced into a spine, or armed with a small tubercle (see Fig. I); dorsum of abdomen with a single area or two spots flavous or rufescent.

  b. Antenniferous tubercles armed with distinct spine at lateral apical angle; male claspers with hook open (see Plate X); connexivum marked with a black vitta on each segment, except in a few rare individuals.

    c. Size small, 9 by 2.5 mm.; six black maculæ in series on venter, other dots minute.. *guttula* Fabricius.

    cc. Size larger, 10 to 12 by 3 to 3.5 mm.; venter covered with black dots about as large as those of series.............................. *mendica* Stal

  bb. Antenniferous tubercles acute externally, but without distinct slender spine.

    c. Pronotum legs, and venter thickly dotted with black; size large, length 12 mm. or more; male claspers with apex of hook not elongate. *apicalis* Dallas.

    cc. Pronotum legs and venter flavous, sparsely dotted; size small, slender; color pale; male claspers with apex of hooks elongate...... *flava* n. sp.

aa. Antenniferous tubercles rounded unarmed; dorsum of abdomen black, connexivum pale, both immaculate; male claspers with hook nearly closed at tip.

  b. Third antennal segment flavous at apex, fourth incrassate; legs sparsely but conspicuously dotted with black......................... *texana* Stal

  bb. Third and fourth antennal segments black, fourth slender; legs paler. *selector* Stal

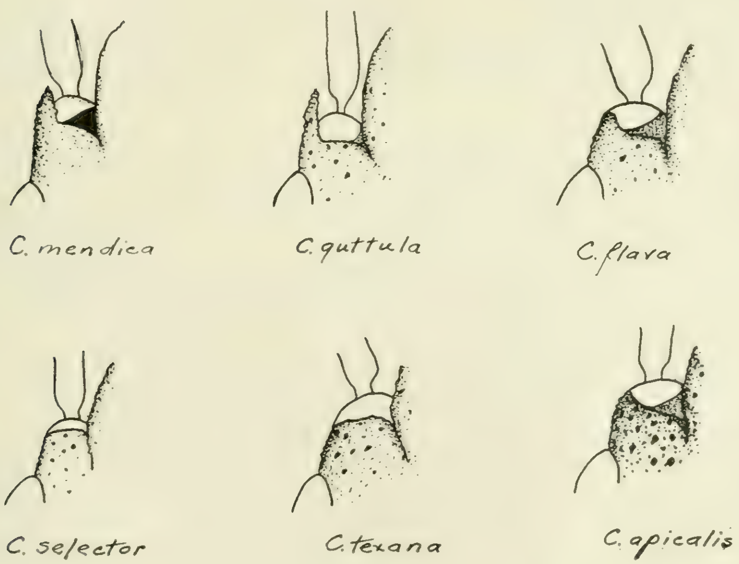

FIGURE I.

Antenniferous tubercles in Catorhintha. Drawings by the author.

C. mendica Stal is the common species of the eastern United States and is known from Florida and Ohio to Wisconsin, Dakota, Colorado, New Mexico and Lower California. It is often found on Xanthium.

In the southern United States, from Florida west, *C. guttula* Fabricius is well known and it has been taken as far north as Colorado.

Catorhintha borinquensis Barber from Porto Rico possesses spinose antenniferous tubercles and resembles *C. guttula* in appearence. It is more reddish in coloration and the male claspers resemble those of *C. flava*, although more slender. The dorsum of the abdoman is brown without a pale spot, and the connexivum is spotted.

One of the types was examined through the courtesy of Mr Barber.

All the other species belong to the fauna of the southwestern states from Colorado and Texas to California.

C. apicalis Dallas is a large variable species of wide subtropical distribution. The present writer has been inclined to divide it into at least two species but a study of the genitalia gives evidence that the different forms may best be described as varieties.

The typical form, variety *apicalis* Dallas, has the terminal antennal segment rosaceous, and the connexivum marked with segmental black spots. Specimens from Arizona (Barber), Mexico (Banks) and California (Van Duzee) have been examined. The male claspers in the specimens dissected were not clavate at the apex but otherwise agreed with the other varieties. (See Plate I).

Variety *scrutator* Distant is said by Distant* to be more common in Central America than the typical form. The last antennal segment is black, being pale at the extreme apex only. The connexivum is spotted as in variety *apicalis*. Distant uses the term *scrutator* in a way which makes its validity doubtful but the present author believes the adoption of a new name at this time would serve no useful purpose. After describing the common form, he says, "This form is also contained in the Berlin museum and was sent to me labeled *scrutator*." Specimens have been examined from Arizona (Barber), California (Illinois, Cornell and Harvard collections) and Colorado (Illinois collection).

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* Biol. Cent. Am. 1, 1881, 139.

In variety *marginata* n. var. the connexivum is immaculate, pale, and the terminal antennal segment black except at extreme apex. A large number of specimens of this variety, including the types, were collected by Dr. E. D. Ball and Mr. E. P. Van Duzee at Salida, Colorado, on July 24, 1900. Since the male claspers are angularly clavate at the apex, differing in this respect from the typical form, the variety may be entitled to specific rank. Several specimens from Van Duzee were in the Cornell collection labeled "Catorhintha texana." The author has seen only a few specimens answering this description outside of that one collection, although over fifteen specimens were secured at that time. The additional ones were from the Huachuca mountains of Arizona in the Barber collection among a number of both sexes of the variety *banksi*.

A few specimens from Arizona, in the Banks and Barber collections have the apical antennal segment pale and the connexivum immaculate, pale. This may be known as variety *banksi* n. var., the type locality being the Huachuca Mountains.

There is a marked uniformity in the size of the different varieties, the total variation being within the limits of 12 to 14 mm. in length and 3.5 to 4 mm. in width.

Carorhintha flava n. sp.

Resembling *C. selector* in form, size, and color, but slightly larger, with the antenniferous tubercles armed with a short appressed tubercle and with the piceous dorsum of the abdomen marked with a longitudinal flavous area.

Body pale yellow, punctate with black above on head and pronotum; legs and ventral surfaces of thorax and abdomen pale excepting the usual prominent black spot on each segment and an additional one near the ventromeson of the first and second ventral segments. Antennæ pale, with the first and fourth segments marked with piceous. Rostrum attaining intermediate coxæ; bucculæ half or more as long as head.

Connexivum pale, immaculate. Apical ventral segment of male flattened and sinuate-emarginate on each side at apex; male claspers with apex prolonged beyond basal portion as shown in Plate X. Size, 11 x 2.5 mm.

Holotype, male, taken at Brownsville, Texas, Dec. 9, 1910; allotype from Lake Lomalda, Texas, November 27, 1910. Both in the collection of the Illinois State Laboratory of Natural History.

C. selector and *C. texana* are very similar to each other, Stal who described them both using the phrase, "*maxime affinis*, * * * *an distincta?*". The flavous apex of the third antennal

segment, the black-speckled legs and the slightly incrassate fourth antennal segment in *C. texana* will serve to separate them. All the specimens seen were slightly smaller than the one Stal described, averaging 3 mm. wide and from 10.5 to 11 mm. long instead of "11.5 by 3.5 mm."

Cimolus.

C. obscurus Stal, a large form from Texas and South Carolina superficially resembles the species of Anasa, but may be distinguished by the short rostrum.

Anasa.

This large neotropical genus is represented in the United States by only seven species, one of which has not been seen since it was originally described. *A. tristis* is one of the best known of all Heteroptera, as it and the chinch bug are the only members of the suborder guilty of extensive depredations. *A. armigera* and *A. repetita* also attack squash, and are of occasional economic importance as far north as Massachusetts;* the former, at least, occurs in Wisconsin.

Stal† has published two extensive synopses of all the then known species. The following key is partially an adaptation of his work and is given here for convenience. *A. obliqua* Uhler is omitted as unrecognized.

a. Head armed with tubercle or short spine behind each antenna or unarmed; last dorsal abdominal segment of male truncate at lateral angles, not sinuate posteriorly.
  b. Head marked with two black or black-dotted vittæ; antennæ and usually legs predominantly black; dorsal tubercles of head present; femora unarmed.
    c. Posterior lateral margins of pronotum sinuate, posterior angles prominent; tubercles of head minute and blunt....................... *tristis* DeGeer.
    cc. Posterior lateral margins of pronotum not sinuate, posterior angles rounded; head with acute little spines.
      d. Anterior angles of pronotum produced beyond caphalic margin as a prominent tooth; body robust,6 x 15 mm................ *uhleri* Stal.
      dd. Anterior angles of pronotum acute, but not produced beyond caphalic margin body slender, 4.5 x 14 mm.................... *andrewsi* Guerin.
  bb. Head without black vittæ, and entirely unarmed; antennæ and legs yellowish brown; size 5 x 13–15 mm.......................... *repetita* Heidemann
aa. Head armed with a long spine on each side, one-third as long as first antennal segment; last dorsal abdominal segment of male sinuate posteriorly next prominent lateral angles; femora with an acute subapical tubercle.
  b. Antennæ (except paler terminal segment) and tibiæ marked with black; central and northern United States........................ *armigera* Say
  bb. Antennæ and tibiæ pale; subtropical.................. *scorbutica* Fabricius

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* Parshley, Jour. Ec. Ent. 11, 1918, 471.

† Hem. Fabr. 1, 1868, 57, and Enum. Hem., 1, 1870, 189.

Zicca.

Z. taeniola Dallas is a West Indian species of which there is a doubtful record of collection in the United States. The armed pronotum and femora distinguish it from other Coreini.

Hypselonotus.

McAtee has recently suggested (l. c., p. 8) that the three recognized forms of this genus in North America be considered synonymous under the name *H. fulvus* DeGeer. In the material at hand all but one specimen shows the spotted venter of *punctiventris* Stal while two others also answer Fabricius' description of *venosus*.

Paryphes.

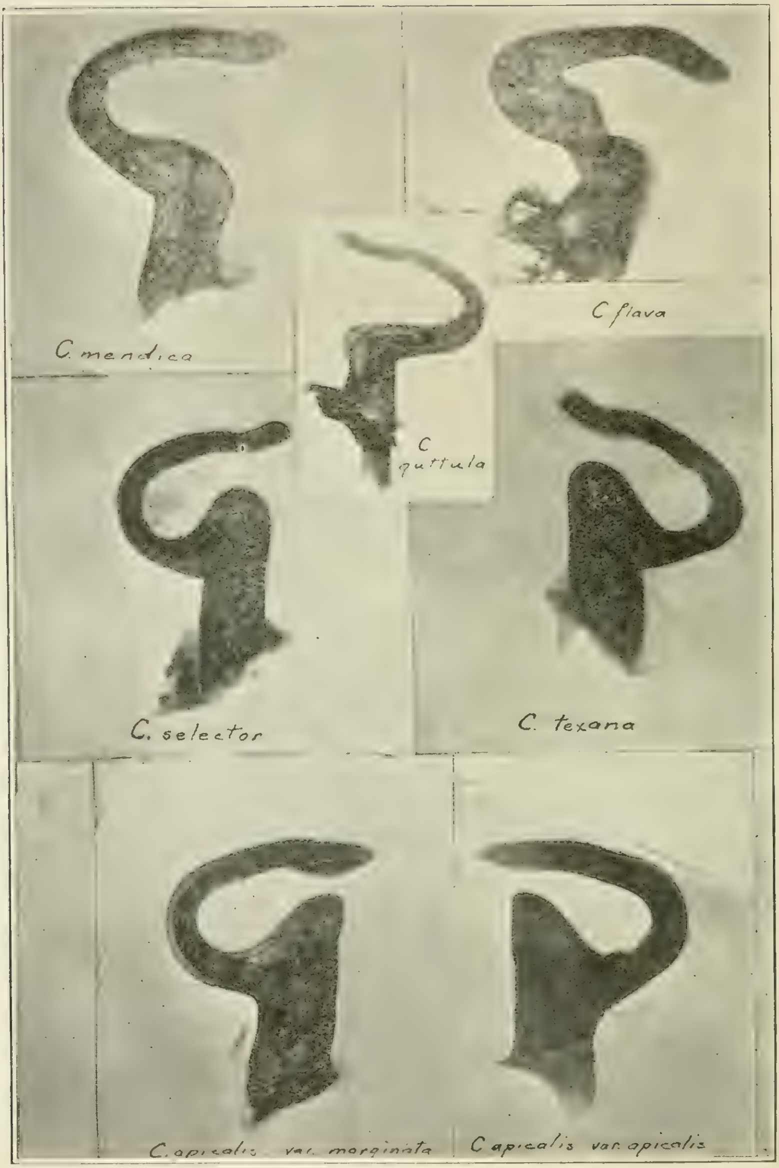
The inclusion of this genus in lists is based on Uhler's report* of *P. rufoscutellatus* Gray in California. This species is not included in Horvath's monograph of the genus and the present author has seen neither specimen nor description.

* Uhler, P. U. S. Geol. and Geog. Surv., Bul. **1**; 1876, 293.

EXLANATION OF PLATE X.

Male claspers in the genus Catorhintha.

Distinctions of importance are (a) the shape of the base, (b) the angle between the base and the hook, (c) the shape of the hook, and (d) the shape of the apex of the hook. Photomicrographs by E. L. Chambers.


C. mendica
C flava
C guttula
C. selector
C. texana
C. apicalis var. marginata
C apicalis var. apicalis

S. B. Fracker.

NOTICE

The attention of Entomologists throughout the world is called to the fact that, beginning with the Volume for 1922, the preparation of the "Insecta" part of the "Zoological Record," is being undertaken by the Imperial Bureau of Entomology. In order that the Record may be as complete as it is possible to make it, all authors of entomological papers, especially of systematic ones, are requested to send separata of their papers to the Bureau. These are particularly desired in cases where the original journal is one that is not primarily devoted to entomology. All separata should be addressed to The Assistant Director, Imperial Bureau of Entomology, 41, Queen's Gate, London, S. W. 7, England.

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AN INTRODUCTORY STUDY OF THE PSAMMOCHARINÆ WITH SPECIAL REFERENCE TO THE AMERICAN SPECIES OF THE GENUS LOPHOPOMPILUS RADOSZKOWSKI.*

By W. S. Regan, Ph. D.

INTRODUCTION.

Some years ago, while a postgraduate student at the Massachusetts Agricultural College, the writer undertook the systematic study of the Psammocharid (Pompilid) digger wasps of the subfamily Psammocharinæ. Through the kindness of many persons, who loaned material from various museums and private collections, several thousand specimens were thus made available for this study. This material consisted of species taken over a wide geographical range, including Alaska, various parts of Canada, the greater part of the United States, Mexico, the West Indies, Central and South America, and in addition many specimens from the Australian, Palearctic and Oriental faunal realms. The writer has also examined most of the type specimens of American species belonging to this subfamily in the various collections both in this country and abroad. These types included those of E. T. Cresson, Sr., Fox, Vierick, Robertson, Banks, Frederick Smith, Cameron and others. Owing to the inadequacy of the original descriptions, it is felt that very little could have been accomplished with this group had not the examination of these types been possible. It was

* Contribution from the Department of Entomology of the Montana Agricultural Experiment Station, Bozeman, Montana.

hoped to have published much earlier but the pressure of teaching duties and economic problems has made this impossible.

Establishment of the Genus Lophopompilus and Synonomy.

In 1887 General O. Radoszkowski established Lophopompilus as a subgenus of Pompilus (Horæ Societatis Entomologicæ Rossicæ, XXI, 1887, p. 42). Radoszkowski designated no type but included under Lophopompilus, in order, the species *grandis* Eversm., *przewalskii* Rad. and *zelleri* Dahlb. This writer, in the publication cited, also figured the male genitalia and referred to the plumose or tufted genital cover ("couvercle genital panache"), a character which clearly distinguishes the males of this genus from those of all other genera of the subfamily. This reference to the plumose genital cover really applies to a sagittate plate attached to and overlying the base of the subgenital plate like a keel. It appears merely as a rather inconspicuous hirsute piece projecting from under the emargination of the penultimate ventral abdominal segment. (Plate XII, Figs. 1, 2 and 4). In 1902 Ashmead erected the genus Pompilogastra, designating *Pompilus æthiops* Cress. as the genotype (Can. Ent. XXXIV, 1902, p. 81). *P. æthiops* Cress. is certainly congeneric with the species placed in Lophopompilus by Radoszkowski. Pompilozastra Ashm. therefore, becomes a synonym of Lophopompilus. In the publication just referred to (p. 84) Ashmead designates *Pompilus grandis* Eversm. as the type of Lophopompilus. *Pompilus grandis*, accordingly, becomes the genotype, or "type by subsequent designation."

Banks (Journ. N. Y. Ent. Soc. XIX, 1911, p. 221) intimated the possibility of synonomy between Pompilogastra and Lophopompilus. He evidently became confirmed in this opinion later as he correctly discards Pompilogastra for Lophopompilus, for *æthiops* and related species. (Bull. Museum of Comparative Zoology of Harvard College, Vol. LXI, 1917, p. 108).

American Species Assignable to the Genus Lophopompilus.

Only four American species can be definitely assigned to the genus Lophopompilus. These species are *atrox* (Dahlb.), *bengtssoni* n. sp., *æthiops* (Cress.) and *cleora* (Banks), all North

American species. No South American species of the genus are as yet known. The species *bengtssoni*, possibly on account of its similar size, color and distribution, has not previously been separated from *atrox*. Both the male genitalia and external morphological characters, however, show these two species to be distinct. *Pompilus ephippiger* Sm. and *Lophopompilus carolinus* Banks, the types of which have been examined by the writer, may possibly belong to this genus, but as there are only two female specimens of the former species and one female of the latter, assignment to this genus at the present time would be purely guess work. Although a great deal of material has been examined, no males have ever been seen which might possibly be those of either of these two species, possessing at the same time the generic characters of Lophopompilus. *L. ilione* Banks is a synonym of *L. æthiops* (Cress.) and *L. autilione* Banks, described from a male specimen and assigned to this genus by the author, is apparently a male of *P. bellicosus* Banks. It does not possess the plumose subgenital plate and therefore does not belong to the genus Lophopompilus. The type specimens of both *ilione* and *autilione* have been examined.

Characters of the Genus Lophopompilus (Pompilogastra Ashm.).

Type: *Pompilus grandis* Eversmann, *Pompilus samariensis* Pall.(?).

Radoszkowski (Horæ Soc. Ent. Ross. XXI, 1887, p. 42) gives the characters of Lophopompilus as—all the characters of Pompilus except that the clypeus is emarginate and the genital cover plumose (translation). This tufted or plumose "genital cover" occurs only in the males and is found in no other genus known to the writer. The emargination of the clypeus in the females is very distinct but does not occur at all in the males. It should be noted that the character of the emarginate clypeus is possessed also by the females of certain other genera. The posterior margin of the pronotum in both sexes is broadly arcuate. Unfortunately the venation is of such a variable character that it can hardly be said to exhibit any distinctive generic peculiarities. The color for the members of this genus shows almost no variation from one of two types for both American and exotic species. It is either black or blue-black or black with the second abdominal segment orange above.

The species are wasps of medium to large size, ranging from about 10 millimeters for the smaller males to fully 25 millimeters for the larger females.

The characters of the genus may be summarized as follows: Medium to large sized wasps (10 to 25 mm.), colored either black, blue-black or black with the second abdominal segment orange above; posterior margin of pronotum, broadly arcuate in both sexes; clypeus of female deeply emarginate; males with a plumose plate at the base of the subgenital plate.

Male Genitalia.

A study of the male genitalia has been found of great help, particularly to supplement or verify certain external morphological characters. In fact it was due to a study of the male genitalia that the separation of *L. atrox* (Dahlb.) and *L. bengtssoni* n. sp. was made possible. Certain structural characters in specimens of these two species at first appeared to be merely structural variations. Later, after the genitalia gave unmistakable evidence of distinct species, these "variations" proved to be constant morphological differences, by which each species could be separated with little difficulty. The extent to which the genitalia can be used for the separation of species within a genus is, however, not without limitations. In Lophopompilus the genitalia show distinct constant differences by which each species can easily be identified. In the genus Batazonus Ashm. and certain other genera the genitalia for all the species are practically identical, although there are excellent external morphological characters by which these species can be separated.

The male genital structure (Plate XI, Fig. 1) is made up of two main parts, a basal portion or cardo, and an apical portion, which is composed of several parts. The cardo appears to show no specific differences. On the apical portion, or genital structure proper, there is (1) a central, rather flexible piece, the uncus, ("crochets" of Radoszkowski), which is incised apically and shallowly notched on each side. Extending from the median apical incision to the base is a chitinous thickening, which marks the division of this organ into two symmetrical halves and forms a longitudinal groove ("fourreau" of Radoszkowski) at the base of which on the ventral side is the

circular penial opening. Situated within the uncus and visible only with the higher magnifications of the microscope, is a longitudinal canal, which extends from the base to near the apex. (Plate XI, Fig. 5). Opening upon the surface of the uncus from this canal are minute pores, many of which are tubulate, and apparently furnished for the most part with microscopic surface spines. These tubular pores present a strikingly interesting pattern, but the arrangement appears to vary considerably, even in different specimens of the same species. (2) To each side of the uncus is a more heavily chitinized, rod-like organ, the saggitta ("la base du forceps" of Radoszkowski). These structures are destitute of hairs or spines and show only minor differences in shape and length as compared with the other structures, even in different genera. (3) Lying laterad to each sagitta is a structure which reminds one slightly by its shape of a bird's head, the apex being directed inward towards the uncus. The ventral surface, especially, of the volsellæ is covered with strong spines, some of which appear to have a tubular connection with a canal inside the structure after the manner of the tubular glands on the uncus. (Plate XII, Fig. 3). The volsellæ show specific differences both in shape and in the nature of the spinous armature.

At the base of each volsella is a group of strong hairs and mediad to these a pair of stout hooks, which are directed inwards. It might be noted that these hooks, here termed the basal hooks, are not present in all genera of the Psammocharinæ. These hooks show only slight differences in shape for the different species of the genus Lophopompilus. Radoszkowski has figured them in some of his plates and has mentioned them in the text. He appears, however, not to have named them.

(4) A pair of lateral organs, one lying laterad to each volsella, here termed the claspers ("branch du forceps" of Radoszkowski). These structures differ considerably in the different species in length and shape and in the nature of the vestiture, which consists of strong, long hairs. The claspers thus afford the most constant and pronounced characteristics of the male genitalia for the separation of the species of Lophopompilus. A small scale-like piece at the base of each clasper appears worthy of a designation, as its location on the

clasper varies in different genera, it even being lacking in some instances. This scale-like structure is here termed the genital squama.

Antennal Sense Organs.

It is not the intention of the present paper to go into morphological detail on this subject. It might be mentioned, however, that these organs are of distinct types in the two sexes and that certain groups of genera have antennal sense organs of a type distinct in structure from those of other groups of genera, the character evidently being of value for the grouping of genera into tribes.

There are two distinct types of antennal sense organs plainly visible under the binocular microscope (16 to 65 or more diameters) on the antennal segments of the females of Lophopompilus. One type, which will be referred to as the longitudinal sense organ, is located on about the anterior third (antennæ considered as extending sideways from the head) of each segment of the flagellum, except the first, on which it is absent near the base. This longitudinal sensitive area has the appearance of being covered with minute pores (Plate XIII, Figs. 3 and 7), but under high power (slide mount) it is seen to be covered with short, bluntly conical pegs, which closely resemble Schenk's "sensillum basiconicum," to which he attributes an olfactory function (Schenk—"Die Antennalen Hautsinnes-organe einiger Lep. und Hym.," Zool. Jahrb. Abth. fur Anat., 17, p. 573). The females of all species throughout the subfamily appear to have this longitudinal sense organ. A second type of sense organ upon the antenna in the females of Lophopompilus is also visible under the ordinary power of the binocular microscope. This consists of two more or less circular, depressed, shining areas on each segment of the flagellum. Each area occupies a central position, lying opposite to the other on the dorsal and ventral surfaces, the longitudinal sense area being between and contiguous to these on the anterior surface. These central sense organs are much larger on the apical segments than on the basal segments and the ventral area is considerably larger than the area opposite on the dorsal side of the same segment (Plate XIII, Fig. 3). These central sense areas are not present in Ashmead's genera Batozonus, Arachnophroctonus, Spilopompilus, Pycnopompilus and certain

other genera. Under high power the central sense areas appear to be dotted with minute pores, each of which gives rise to a slender bristle. It is probable that these organs have an auditory function.

In the males neither of the antennal sense organs described for the females occurs. The common type of antennal sense organ in this sex, with few exceptions, notably in Batozonus Ashm. and Poecilopompilus Ashm., occurs in the males throughout the subfamily. This sense organ consists of a light colored area covering the anterior half of all the segments of the flagellum, except the extremity of the apical segment. Sparsely set over this sensitive area are minute, erect, stout spines (Plate XIII, Fig. 4). Exceptions to this type of sense organ are to be found in the males of species of Batozonus Ashm. and Poecilopompilus Ashm. Here the only sensitive area visible under ordinary binocular magnification consists of a circular, depressed, shiny area at the base of each segment of the flagellum on the ventral side (Plate XIII, Fig. 6). These areas are especially conspicuous on the antennæ of species having dark colored antennæ, such as *Batozonus algidus* (Sm.)

Characters of Specific Value in the Genus Lophopompilus.

While a certain structure may be primarily of generic rank, that is, possessed in common by all species of a genus, there may be, nevertheless, some modification of this particular structure, which proves fairly constant for all specimens of distinct species, thus making the character of specific value also. For instance, the emargination of the clypeus in the female is a character common to all species of Lophopompilus, it thus being a generic character. In *L. atrox*, however, this emargination is narrow and deep, whereas in *L. bengtssoni* it is broad and shallow, this character, therefore, being of specific value in separating these two species. Unfortunately the emargination of the clypeus cannot be used for the males, as it does not occur in this sex. Another character of specific value, but one not available for use in all species of the genus is the comparative convergence of the eyes at the top of the head, and the comparative length of the postocellar and ocellocular lines. This character is especially advantageous in separating the species *atrox* and *bengtssoni*. The number and character of the anterior

metatarsal comb spines, although somewhat variable, nevertheless affords excellent means for separating the species of this genus. Here also this structure, although present in the males, is only weakly developed and therefore not as satisfactory a character as for the females.

Other characters that can occasionally be taken advantage of for separating species in this genus are color, vestiture, venation and slight differences in the thoracic structure. The male genitalia, as previously pointed out, offer excellent characters by which the species can be separated without difficulty, the claspers on this structure showing the most pronounced specific differences. This character cannot, however, be made use of for the ordinary key separation of species. The degree of excretion of the plumose plate at the base of the subgenital plate in the males appears to be fairly constant in some species and may, therefore, be resorted to, especially since in this sex the external characters for the separation of species are few in number. The use of separate keys for the two sexes is practically a necessity, as some of the excellent characters possessed by the females are lacking in the males.

It should be noted that even the most satisfactory and reliable specific characters in this group are somewhat variable. It is impossible to state that a certain character is invariably of a definite structure. It is only by taking the usual condition which obtains with respect to the more stable characters and by combining these with as many other characters peculiar to the species in question as possible that any degree of accuracy can be attained in the determination of closely allied species. Excluding the genitalia from consideration, the males of allied species are especially difficult to separate, on account of the frequency with which the characters overlap.

Key for Separation of Species of Lophopompilus.

(Females.)*

Color black, second abdominal segment orange above.

Emargination of clypeus broad and shallow; eyes converging more above, so that the postocellar line is longer than the ocellocular line; ocelli large and moderately prominent; anterior metatarsal comb spines usually four in number, the basal one sometimes reduced; basal and transverse median veins of the fore wings usually interstitial on the median vein, or these veins slightly disjoined, when disjoined the basal vein usually originating beyond the transverse median. . . *bengtssoni* (1)

Emargination of clypeus narrow and deep; eyes converging less above, so that the postocellar line is shorter than the ocellocular line; ocelli smaller, not prominent; anterior metatarsal comb spines usually three in number, occasionally a smaller fourth spine on one or both legs; basal and transverse median veins usually slightly disjoined on the median vein, the basal vein originating before the transverse median, rarely interstitial. . . . *atrox* (2)

Color, blue-black.

Edge of clypeus thickened and margined; its emargination broad and shallow and rounded where it meets the lower margin of clypeus; front convex, full between eyes, postocellar line distinctly shorter than ocellocular line; anterior metatarsal comb spines three in number, rarely with a smaller fourth, the terminal spine scarcely more than half the length of the second tarsal segment; metathorax with a moderately abrupt slope posteriorly and at the sides. . . . *æthiops* (3)

Edge of clypeus thin, its emargination rather deep, clean cut, and angled where it meets the lower margin of clypeus; front nearly vertical, head narrower antero-posteriorly, postocellar and ocellocular lines nearly equal; anterior metatarsal comb spines consisting of four long, strong spines, the terminal spine (if not worn) distinctly more than half the length of second segment; metathorax rounded posteriorly and at the sides. . . . *cleora* (4)

Key for Separation of Species

(Males.)†

Color, black, the second abdominal segment orange above.

Eyes converging more above, so that the postocellar line is longer than the ocellocular line; ocelli larger and moderately prominent; basal and transverse median veins of the fore wings usually interstitial on the median vein, or these veins slightly disjoined, when disjoined the basal vein usually originating beyond the transverse median; metathorax usually with an abrupt slope posteriorly. . . . *bengtssoni* (1)

Eyes converging less above, so that the postocellar line is shorter than the ocellocular line; ocelli smaller; basal and transverse median veins of fore wings usually slightly disjoined on the median vein, the basal vein originating before the transverse median, rarely interstitial; metathorax with a gradual slope posteriorly. . . . *atrox* (2)

Color, blue-black.

Front convex, full between eyes, postocellar line distinctly shorter than ocellocular line; anterior metatarsal comb spines three in number; plumose piece at base of subgenital plate exserted but little, more often with merely a tuft of hair evident. . . . *æthiops* (3)

Front nearly vertical, head narrower antero-posteriorly, postocellar and ocellocular lines nearly equal; anterior metatarsal comb spines four in number, the basal spine minute; plumose piece at base of subgenital plate exserted for nearly its entire length. . . . *cleora* (4)

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* The females have 12-segmented antennæ and dentate claws.

† The males have 13-segmented antennæ and cleft claws.

(1) **Lophopompilus bengtssoni** n. sp.*

Type—National Museum, Washington, D. C. Paratype, Am. Ent. Soc. Collection, Philadelphia; Montana State College Collection, Bozeman, Mont.; Massachusetts Agricultural College Collection, Amherst, Mass.

Distribution—New Hampshire, Durham, Hedding, Sept. 22, 1916; Massachusetts, Springfield, Amherst, July 28, 1890, July 6, 1900, August, 1909, September 14, 1916; Rhode Island; New York, Long Island, Fishers Island; Pennsylvania, October, 1908; North Carolina, Smith's Island, October, 1906; Georgia; Florida, Texas, Rosser, Dallas, August 5, 1908; Kansas, Meade County, Riley County, July 3; Illinois.

♀—Black, with a bluish tinge, second abdominal segment orange above on the anterior two-thirds of the segment, the band faintly interrupted in the middle and emarginate posteriorly; wings uniformly fusco-violaceous; emargination of clypeus broad and shallow (Plate XIII, Fig. 5); inner orbit of eyes slightly diagonal, the eyes converging somewhat above, so that the postocellar line is slightly longer than the ocellocular line; ocelli large, somewhat prominent, but front between eyes with a suggestion of concavity; anterior metatarsal comb spines four in number, the basal one sometimes smaller than the others, (Plate XII, Fig. 5); third cubital cell narrowed but little on the radial vein, basal and transverse median veins usually interstitial on the median vein, or these veins slightly disjointed; when disjointed the basal vein usually originating beyond the transverse median; cubitus of hind wings usually interstitial with the transverse median or arising before it scarcely more than the width of one of these veins; metathorax with a rather abrupt slope and somewhat flattened or concave posteriorly. Length, ♀, 15 to 25 mm.

♂—Similar to the female in color and venation; eyes converging above as in the female and postocellar line usually longer than ocellocular line, but this character often less distinct in the males than females; ocelli as in female, but front fuller between eyes than in the female; anterior metatarsal comb spines variable in number, even on the tarsi of the two legs of the same individual, often four in number, the basal spine weak and sometimes absent on one metatarsus, occasionally three on both legs; metathorax with a rather abrupt slope and somewhat flattened or concave posteriorly. Length, ♂, 13 to 19 mm.

Male genitalia (Plate XI, Fig. 1). This species is distinguished especially by the broad, flat claspers and the erect, narrow volsellæ.

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* Named after Dr. Simon Bengtsson, Curator of the Entomological Museum of the University of Lund, Lund, Sweden.

(2) **Lophopompilus atrox** (Dahlb.)*

Pompilus atrox Dahlbom, Hymen. Europ. I, 1843, p. 63.

Type, ♀, Museum of the University of Lund, Lund, Sweden.

Distribution.—Massachusetts: Amherst, July 10, 1895, Aug. 2, 1910, Springfield; New York: Ithaca, July 8, 1885, Long Island, Aug. 22; New Jersey: Anglesea, Aug. 8, 1901; Pennsylvania: Philadelphia; Delaware; Maryland: Chestertown; North Carolina: Raleigh, Oct. 1, 1900, July 10, 1902, Nov. 28, 1908, Wilkesboro, Aug. 9, Blowing Rock, Aug., 1906, Highlands, Sept., 1906, Smith Island, Oct., 1906; South Carolina; Georgia: Thomasville; Florida; Alabama: April 6, Oct. 14, 1903; Louisiana; Tennessee: Knoxville, May 12, 1891; Virginia: Richmond; Montana: Musselshell, Aug. 23, 1917, Aug. 23, 1915.

♀—Colored exactly like the preceding species; emargination of clypeus narrow and deep, (Plate XIII, Fig. 8); inner orbit of eyes almost a straight line, less diagonal and eyes converging less above than in *L. bengtssoni*, so that the postocellar line is slightly shorter than the ocellocular line; ocelli smaller than in preceding species and front full between the eyes; anterior metatarsal comb spines usually three in number, but occasionally with a small fourth spine on one or both legs, the one nearest the base usually the weakest, (Plate XII, Fig. 6); wings of the same color and cell arrangement as the preceding species; basal and transverse median veins usually slightly disjointed on the median, the basal vein originating before the transverse median, rarely entirely interstitial; cubitus of hind wings interstitial with the transverse median or arising but little or considerably before it in different specimens; metathorax with a more gradual slope posteriorly than in the preceding species. This species is on the average slightly smaller than *L. bengtssoni*. Length, ♀, 13 to 22 mm.

♂—Color similar to the female, blue-black with the second abdominal segment orange bove, a few specimens with a small spot of the same color on each side anteriorly of the third segment also; shape of head and relation of ocelli to eyes as in the female, except that in some specimens this character appears to be somewhat variable, in such specimens the postocellar line being about equal or even slightly longer than the ocellocular line; anterior metatarsal comb spines three in number, rarely with a minute fourth on one metatarsus; venation of wings similar to that of female; metathorax gradually sloping posteriorly. Length, ♂, 12 to 17 mm.

* The identification of this species was made possible through the kindness of Dr. Bengtsson, Curator of the Entomological Museum of the University of Lund, Lund, Sweden, who examined the type.

Male genitalia (Plate XI, Fig. 2). The genitalia of this species are distinguished from the preceding by the shorter and narrower clasper, by the broader volsellæ and by the sparser and weaker hairs at the base of the volsellæ.

(3) **Lophopompilus aethiops** (Cress.)

Pompilus æthiops Cress., Proc. Ent. Soc. Philadelphia IV, 1865, p. 451, ♀; Trans. Am. Ent. Soc. I, 1867, p. 87, ♂ ♀.
Syn. *Psammochares ilione* Banks, Psyche, XVII, 1910, p. 249.

Type.—♂ ♀, Am. Ent. Soc. Collection, Philadelphia.

Distribution.—This is the most common and most widely distributed species of the genus. Vermont: Weston, July 31, 1901, Winooski, Aug. 14, 1901; Massachusetts: Amherst, Aug. 13, 1904, Sept. 15, 1914, Cambridge, Worcester, Nantucket, Aug. 16, 1911, Sept. 8, 1907; Rhode Island; New York: Ithaca, Aug. 8, 1903; New Jersey: Riverton, Sept. 8, 1901; Pennsylvania: Philadelphia, Sept. 7, Mt. Airy, Sept. 14, 1901; South Carolina; Nebraska; Missouri; Colorado; Arizona: White Oaks, July 21, 1902, Beulah, Aug. 17; Montana: Huntley, July 19, 1917, Aug. 23, 1915, Billings, July 30, 1910, Powderville, July 14, 1916, Laurel; Washington: Pullman, Aug. 26, 1908, Camp Umatilla, June 27, 1862, June 27, 1882, Yakima River (Lonetree) June 30, 1882, Wawawai, Sept. 6, 1908; California: Stanford Univ., Aug. 26, 1909, Sept., Oct., 1902, Palo Alto, May 7, 1910, June 11, 1896, Sept. 17, 1892; Mexico: Meadow Valley, Barbados.

♀—Blue-black; wings fusco-violaceous; edge of clypeus somewhat thickened and margined, its emargination rather broad and shallow, rounded where it meets the lower margin of the clypeus; front full between the eyes, convex antero-posteriorly; postocellar line distinctly shorter than the ocellocular line; anterior metatarsal comb spines three in number, rarely with a smaller fourth spine on one or both metatarsi; third cubital cell of fore wings narrowed little on the radian vein in some specimens, half or more in others, basal and transverse median veins either interstitial on the median vein or the basal originating slightly before the transverse median, position of cubitus and transverse median veins of hind wings variable, the cubitus usually originating slightly or considerably before the transverse median, occasionally these veins interstitial; metathorax with a moderately abrupt slope and somewhat flattened or concave posteriorly, rather abruptly sloping to the sides. Length, ♀, 13 to 23 mm.

♂—Color similar to the ♀; shape of head above and position of ocelli with respect to eyes as in the female; anterior metatarsal comb spines three in number; venation similar to the female; metathorax

rounded, slightly flattened or concave posteriorly; plumose piece at base of subgenital plate exserted but little and often with only a tuft of hair exposed through the emargination of the penultimate segment. Length, ♂, 9 to 16 mm.

Male genitalia (Plate XI, Fig. 3). This species is characterized especially by the comparatively long claspers, which are slightly enlarged and curved apically, and by the strongly curved and rather bluntly pointed volsellæ.

(4) **Lophopompilus cleora** (Banks).

Psammochares cleora Banks, Bull. of the Museum of Comparative Zoology at Harvard College, Vol. LXI, 1917, p. 105.

Type, ♀, Museum of Comparative Zoology, Harvard College, Cambridge, Mass.

Distribution.—This species is rather rare but appears to have quite a wide distribution. Massachusetts: Provincetown, June 29, 1891; Nantucket, Aug. 20, 1911, Sept. 5, 1907, Sept. 8, 1909; New York: Ithaca, Long Island, Rockaway and Wading River, Aug.; New Jersey: Ocean City, Sept., 1905, Anglesea, Aug. 8, 1901; Maryland: Chesapeake Beach, Sept. 21; Michigan: Huron Co., July, 1908; Montana: Laurel; Lower California: El Paraiso, May, 1889, Los Angeles, May 3 (Banks).

♀—Blue-black, with wings fusco-violaceous as in aethiops; edge of clypeus thin, emargination rather deep, clean cut and angled rather sharply where it meets the lower margin of the clypeus; front nearly vertical, the head comparatively narrow antero-posteriorly, postocellar and ocellocular lines about equal; anterior metatarsal comb consisting of four long, strong spines, sometimes with a smaller fifth comb spine on one or both metatarsi; also two small spines above the comb spines near middle of metatarsus, (Plate XII, Fig. 7); third cubital cell of fore wings narrowed little to one-half or more on the radial vein, basal vein usually originating slightly before the transverse median, occasionally these veins interstitial, cubitus of hind wings originating slightly or considerably before the transverse median; metathorax rounded posteriorly and at the sides, less abrupt than in *aethiops*. A smaller species than *aethiops*. Length, ♀, 13 to 15 mm.

♂—Color, shape of head, position of ocelli with respect to eyes and venation as in the female; metatarsal comb spines four in number, the fourth usually minute; metathorax gently sloping, rounded on all sides; plumose piece at the base of the subgenital plate usually exserted for nearly its entire length. Length, ♂, 10 to 13 mm.

Male genitalia (Plate XI, Fig. 4). This species is distinguished especially by the comparatively short claspers, which are rounded and but little widened apically. The volsellæ are more erect and more bluntly rounded apically than in *æthiops*.

ACKNOWLEDGMENTS.

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EXPLANATION OF PLATES.

Plate XI.

Fig. 1. Genitalia of *L. bengtssoni*, ♂.

uc—uncus.
sg—sagitta.
vo—volsella.
cla—clasper.
gs—genital squama.
bh—basal hook.
po—penial opening.
co—cardo.

Fig. 2. Genitalia of *L. atrox*, ♂.
Fig. 3. Genitalia of *L. æthiops*, ♂.
Fig. 4. Genitalia of *L. cleora*, ♂.
Fig. 5. Enlarged drawing of uncus of *L. cleora*, showing tubulate pores.

Plate XII.

Fig. 1. Plumose plate (B) at base of subgenital plate (A) in the males of the genus Lophopompilus.

Fig. 2. Penultimate ventral abdominal segment in the males of the genus Lophopompilus, showing emargination (C) under which the tip of the plumose piece (B) in Fig. 1 is exserted (see Fig. 4).

Fig. 3. Enlarged drawing of volsella of *L. cleora*, showing armature and tubulate glands.

Fig. 4. Side view of abdomen of ♂ *L. atrox*, showing exserted plumose plate (B) indicated in Fig. 1, B.

Fig. 5. Anterior metatarsal comb spines (4) in ♀ *L. bengtssoni.*

Fig. 6. Anterior metatarsal comb spines (3) in ♀ *L. atrox.*

Fig. 7. Anterior metatarsal comb spines (4) in ♀ *L. cleora.*

Plate XIII.

Figs. 1 and 2. Fore and hind wings of *L. atrox.*

a—anal vein.
ac—anal cell.
am—apical margin.
b—basal vein.
bl—basal lobe.
c—costal vein.
cc—costal cell.
cu—cubital vein.
cu_1—first cubital cell.
cu_2—second cubital cell.
cu_3—third cubital cell.
d—discoidal vein.
d_1—first discoidal cell.
d_2—second discoidal cell.
d_3—third discoidal cell.
fh—frenal hooks.
m—median vein.
mc—median cell.
r—raidal vein.
rc—radial cell.
re_1—first recurrent vein.
re_2—second recurrent vein.
s—stigma.
sc—subcostal vein.
sd—subdiscoidal vein.
sm—submedial cell.
sr—stigmal region.
tc—transverse cubitus.
tc_1—first transverse cubital vein.
tc_2—second transverse cubital vein.
tc_3—third transverse cubital vein.
tm—transverse median vein.

Fig. 3. Segments of antenna of female *L. bengtssoni*, showing longitudinal and central sense areas.

Fig. 4. Segments of antenna of male *L. bengtssoni*, showing sensitive area.

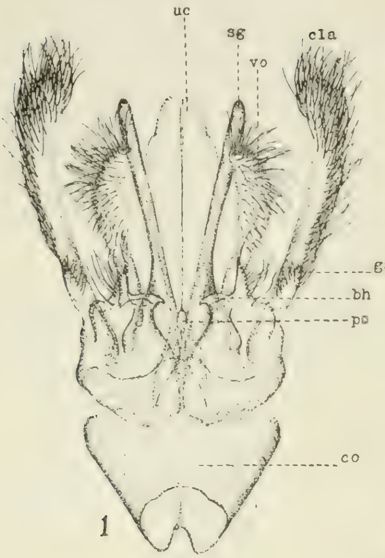
Fig. 5. Head of *L. bengtssoni.*

cf—clypeo-frontal suture.
cl—clypeus.
f—frons.
lb—labrum.
md—mandible.
ms—malar space.
ol—ocellocular line.
pl—postocellar line.
s—scrobes.

Fig. 6. Segments of antenna of male *Batozonus algidus*, showing sensitive area.

Fig. 7. Segments of antenna of female *Batozonus algidus*, showing sensitive area.

Fig. 8. Head of *L. atrox.*



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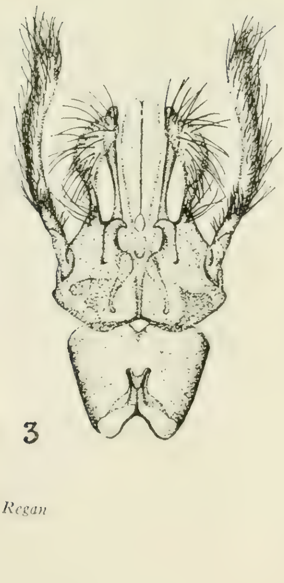

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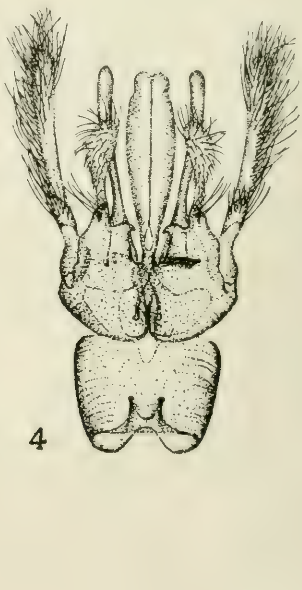

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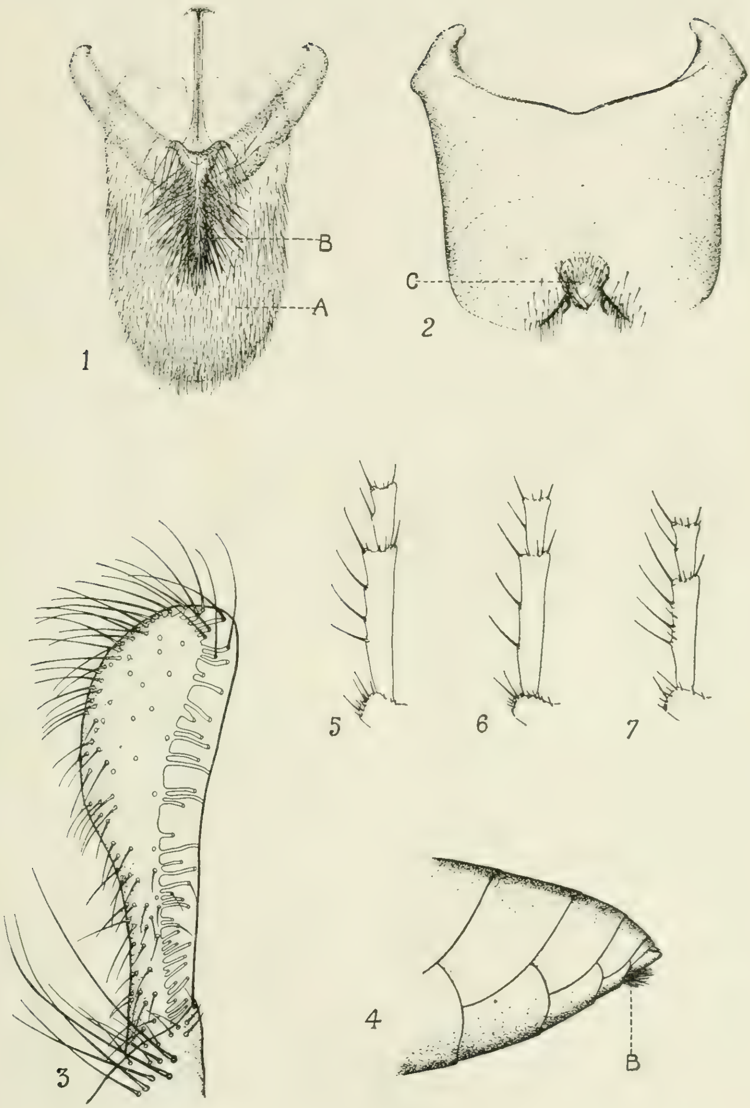

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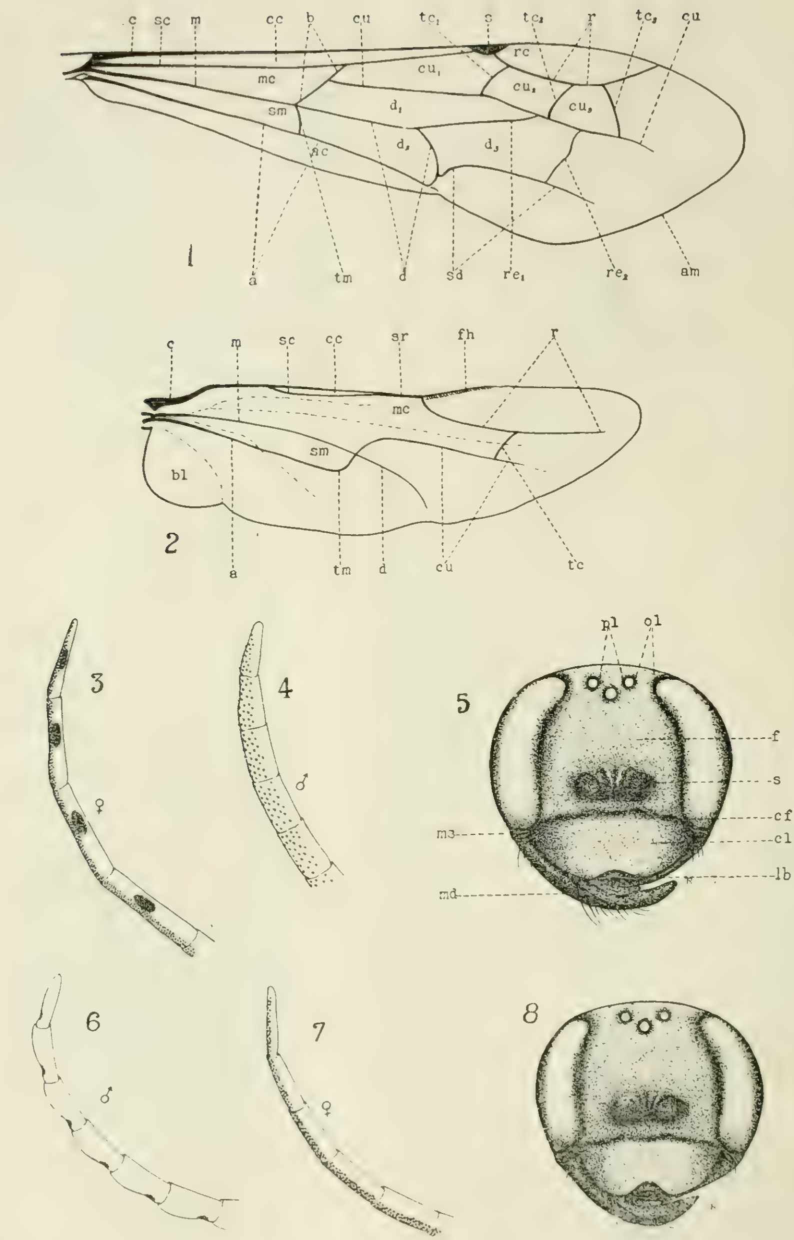
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THE BIOLOGY OF SCHIZASPIDIA TENUICORNIS ASHM., A EUCHARID PARASITE OF CAMPONOTUS.

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Introductory.

During the summer of 1921, while engaged in the study of the parasites of *Popillia japonica* at Koiwai, Iwate-ken, Japan, the writer occasionally made miscellaneous collections of parasitic Hymenoptera by sweeping. Among those secured was found at times numbers of a large metallic-green Eucharid. Realizing that the biology of this very interesting family of Chalcids had never been studied in detail, an effort was made to determine the habits of this species. In the localities where the parasite was abundant the large *Camponotus herculeanus* sub-sp. *japonicus* Mayr was very numerous, and was the only species of sufficient size to serve as host to the Eucharid. Several nests were therefore excavated, and the presence of the parasite in numbers in the cocoons was at once established.

The crucial point in this life-history was undoubtedly that of the place and manner of oviposition, as early experiments demonstrated that this did not occur in the normal manner. Sweepings of grass and weeds in the general vicinity of the nests produced a predominance of males over females in the ratio of about ten to one, an abnormal condition and one which led to the presumption that the greater proportion of the females were engaged elsewhere. Increased success resulted from sweepings on the lower branches of nearby chestnut trees, and this naturally induced a closer examination to determine the purpose of their presence in these places. A few days later, when attempting to capture a single female seen perched upon a chestnut bud, it was found that this individual had her ovipositor deeply inserted in the bud, in fact so much so as to be unable to withdraw it. An examination of the interior of this bud was then made, and there was revealed a large mass of very minute eggs closely packed within the terminal portion.

Being now in possession of what seemed to be the key to the problem, further observations were made in the same vicinity, and very soon hundreds of females were found ovipositing in an identical manner and place, and the egg-mass first seen was proved to be that of the parasite under observation. This important feature in the biology of the species thus being revealed, it remained to connect up the various stages, etc., to determine particularly the manner in which the larvæ from these eggs gain access to the *Camponotus* pupæ within cocoons in the soil. It soon became evident, however, that hatching was not to take place during that season, but that the eggs would remain in the buds throughout the winter. The investigations were thus brought to a close for the time being, to be continued and completed during 1922. The life-history as finally determined revealed a condition of affairs with hardly a parallel among the parasitic Hymenoptera.

Life-History of Schizaspidia tenuicornis Ashm.

Oviposition. As previously mentioned, the eggs are placed en masse within the buds of various trees, and pass the winter in this condition. The half-dozen or so buds at the terminal end of the young shoots were much preferred for this purpose. At Koiwai the favorite tree for oviposition was the wild mulberry (*Morus alba* L. var.), with the chestnut (*Castanea sativa* Mill.) ranking next. Occasional individuals were also seen to oviposit in white birch (*Betula* sp.). During the latter part of June, 1922, Mr. J. L. King observed egg-laying in the buds of oak (*Quercus mongolica* Fisch.) at Suigen, Korea, while Mr. K. Sato, of this station, noted the same thing in the large, fleshy buds of *Cladastis amurensis* B. et H. var. *floribunda* Maxim at Jozankai in Hokkaido, the most northern of the main islands of Japan. Further investigations in different localities will undoubtedly extend this list.

A comparison of the buds of these various trees shows that all have certain physical characters in common. They are non-resinous, and with the interior somewhat loosely packed, thus giving sufficient space for the egg-mass without undue pressure. Also, the buds of resin producing trees are usually too hard to permit of penetration by the ovipositor of *Schizaspidia*. It seems extremely probable that these physical characters alone

determine whether or not a plant species is suitable as a depository for the eggs of this type of parasite.

The number of eggs deposited by a single female was found to range from 940 to 1230, with a general average of 1050 for twenty-five egg-masses taken from buds in the field, and this was verified by a count of the mature eggs in the ovaries of the adult females. This number is in excess of that known for any other parasitic hymenopteron, and is a criterion of the mortality which must occur through the difficulties to be surmounted before the planidia finally gain access to the host larvæ in the nest beneath the surface of the soil.

The female penetrates the bud scales by the use of the ovipositor and sheaths combined, these being barbed at the tips. The point of insertion is invariably on the distal half, and usually on the upper side, though occasionally through the tip. The oviposition scars on the surface scales are evident as raised blackened spots about .5 mm. in diameter. On the inner scales the point of perforation is conspicuous as a much darkened area on the light green surface. The proper penetration of these scales to the interior of the bud requires about five minutes labor on the part of the female, and after this is completed the actual deposition of eggs begins. Under normal conditions the entire quota of eggs of the female is discharged at this one time, and is completed within an average period of twenty minutes. This represents a rate of oviposition of nearly one egg per second over the entire period, a most striking and unusual phenomenon, and comparable in rapidity to that of *Termes bellicosus* (Smeathman 1781) and *Pterodontia flavipes* (King 1916), though of much shorter duration.

The stalked eggs, having passed through the ovipositor, lie free within the bud cavity, or the space normally occupied by the tips of the inner scales and the pubescence, and all are liberated at approximately the same point. As the eggs continue to issue from the ovipositor tip those first laid are forced further and further away. This force, being always from the center of the mass outwards, tends to arrange the eggs in irregular concentric circles about this point, with the stalks directed somewhat towards the center.

The completed egg-mass, comprising a thousand or more eggs, conforms in outline to the space available in the bud. Usually it approximates 1.5 mm. in length, slightly less in width,

and of varying depth. Its center on the outer surface is represented by a hard, dark-brown mass, of about the volume of half a dozen eggs, which may be either a hardened fluid given off by the female at the time of oviposition or merely an exudation of sap from the lacerated tissues of the inner bud scales.

The number of these egg-masses within a single bud may be determined approximately by a count of the oviposition scars on the surface. As many as twenty-four, of normal size, have been taken from a single large mulberry bud collected in the field. In such cases the composite mass has a pronounced stratified appearance due to the difference in age of the successive individual egg-clusters. Figure 1 of Plate XV shows two egg-masses of characteristic form and position within a mulberry bud. That on the left is freshly laid, while the other is about twenty days old and consequently much darkened.

The one tree in the buds of which the greater proportion of the eggs were laid was a small mulberry bush about seven feet high, and not heavily branched, growing in a strip of waste land. In 1921, from a count of the twigs bearing buds suitable for oviposition, it was estimated that approximately six hundred buds were available for oviposition by *Schizaspidia*. Eighty-five of these were cut open and examined under the binocular. Every one was found to contain eggs, and the average was 7.2 masses per bud. Allowing one thousand eggs per mass, this being very near the general average as determined by actual count, we secure the almost unbelievable total of 4,320,000 within the buds of this single shrub. In the case of a few buds the pressure had become so great through excessive oviposition that a small number of eggs were actually forced out through one or more of the puncture holes. At times every bud on a twig would bear one, and sometimes two, females in the act of oviposition.

Oviposition on bright days occurs largely during the morning from 9:00 A. M. to 12:00 M., though a few individuals could be seen here and there during the afternoon until as late as 4:00 P. M. These late females were largely those which had been disturbed during the morning hours and had not succeeded in relieving themselves of their burden of eggs.

The Egg Stage.—When first laid the stalked eggs are white in color, but at the end of about fifteen days they show a pronounced darkening due to the development of the embryo

within. After twenty days the larva is fully formed and its general characters may be readily distinguished through the transparent chorion. Under the binocular the latter is seen to give off brilliant irridescent reflections. The general color of the mass itself is a deep amber. The larva occupies less than half the volume of the egg, and the remainder is filled with a nutrient fluid of a colloidal nature, and immersed in this medium the larva remains through the winter. At this time the body segments are lightly chitinized and the large head fully formed.

During the early spring when tree growth begins (mulberry the latter part of April at Koiwai, chestnut about two weeks later) the flower buds first swell and burst through their scaly covering, being followed shortly by the leaf buds. As the heavy scales which have protected them during the dormant season fall away it is seen that the *Schizaspidia* are firmly attached to the fine, leaf-like inner scales. They are now exposed to the sun, rain, and other detrimental influences, and finally fall to the ground. In the very humid climate prevalent at Koiwai these mold very quickly, and none remain from the opened buds to reproduce the species. By May twentieth no exposed egg-masses could be found on the trees or elsewhere. The same course of events took place in the case of chestnut buds a few weeks later.

Upon the trees, however, there still remains a considerable number of buds which have failed to develop, and within these the remaining eggs are contained which serve to perpetuate the species. Being dead, these buds eventually dry out, and some open slightly, thus producing a means of egress for the imprisoned larvæ after hatching. The same result is secured in other buds by the feeding of bud-moths and other insects.

During the spring months the larva within the egg completes its development, apparently consuming the greater portion of the fluids surrounding it and leaving only the remnants of the amnion and a granular residue at the anterior end. Hatching is effected by a break in the chorion near the posterior end, this taking place during July, though live, unhatched larvæ were found in buds as late as August 28th.

First Larval Stage (Plate XV, Figs. 2–5).—The newly hatched planidia, scarcely more than one-tenth of a millimeter in length, are capable of locomotion to a limited degree. This is accomplished by a looping movement wherein the suctorial

mouthparts are attached to the surface and the small attachment disk of the caudal segment brought forward into position, after which the head is again moved forward. The heavy paired spines on the four caudal segments, and particularly those of the last two, assist in bracing the body when the planidia are in a more or less upright position, as when waiting for some insect or other object to which to attach themselves. This position is not at right angles to the surface of the object, but consists merely in the elevation of the anterior two-thirds of the body to an angle of about forty-five degrees. When in this alert position the planidium extends its mouthparts much as illustrated in Figs. 2 and 3, but during cool periods, or when resting, these are retracted into the body, and the heavy dorsal "plate" of the head is brought to a position at right angles to the axis of the body, and appears as a much darkened base upon an inverted cone, as represented by the body proper.

By the looping movement above referred to the larvæ succeed in making their way out of the buds which have sheltered them for so many months. This being accomplished, they wait about for some means of transportation to the ant nest. At this time the mulberry trees are laden with ripe fruit, and chestnut trees frequently have heavy infestations of aphis. The workers of *Camponotus* visit these trees in numbers to feed upon the decaying fruit and upon honey-dew, and in their movements about the twigs and foliage give the parasite larvæ an opportunity to attach themselves to the hairs of the tarsi and other portions of the body. Figure 13 illustrates the position in which several of these were found.

Having now arrived at the nest the larvæ may eventually be brushed off during the movements of the workers about the chambers among the larvæ or they may be removed during the process of cleaning indulged in by the workers after a foray in search of food. They manage, largely by chance, to become attached to the ant larvæ and, after moving about over the body for a time settle dorsally in one of the sutures between the head and the first thoracic segment, or between the first two of the latter. The mandibles are then imbedded firmly in the derm of the host and no further movement takes place.

Second Larval Stage (Plate XV, Fig. 6).—The larva moults by a transverse dorsal split in the derm of the thoracic regions, and the posterior portion of the exuvium is sloughed off cau-

dally, while the head of the second stage larva is lifted out of the anterior portion and reapplied to the host at a point slightly behind the previous one. A form more characteristic of the greater proportion of ectoparasitic larvæ is now assumed. The mouthparts are suctorial, with no evidence of mandibles. Attachment to the host is maintained by means of the adhesive pad made up of the cast skin of the first stage, the mandibles of which are still firmly imbedded in the derm. In dorsal view the head "plate" of the exuvium is visible on the antero-ventral margin of the first thoracic segment. With the parasite in this stage the semipupa of *Camponotus* is clearly evident within its envelope, and within a short time a rupture appears on the median dorsal line of the thorax, the exuvium then being gradually forced back over the body and finally placed at the posterior end of the cocoon. During the process of ecdysis the parasite larva struggles to free itself from the cast skin and, eventually succeeding, works its way slowly back to the desired position on the body of the newly formed pupa. With its very limited powers of movement this reattachment is possible largely because the pupa is now enclosed within its cocoon, thus retaining the parasite in close proximity to its own body. It was a rather remarkable and unexpected development to find that the second stage, rather than the first, effected this transposition from the host larva to the pupa, and it would seem that this is a further handicap imposed upon the species. It would appear more logical for the first stage to continue until the final place of development is reached.

The place of attachment to the host pupa is almost invariably on the metathorax, just underneath the wing-pads or the hind legs, though in a few cases observed the larvæ were slightly more caudad, being on the first abdominal segment. Development now takes place very rapidly, and the second moult occurs within twenty-four hours after the transformation of the host.

Third Larval Stage (Plate XV, Fig. 7).—Having now reached the final larval stage growth becomes very rapid. The position on the host pupa is identical with that of the late second stage. The mouthparts are strictly suctorial, and with no evidence of mandibles. The oral orifice is surrounded by a lightly chitinized ring, and within the buccal cavity is the sharp, stilleto-like "plunger," which serves to perforate the derm of the host and

to keep the aperture open. In living individuals this can be seen moving back and forth with the regularity and almost the speed of a trip-hammer, and functioning as the piston within a cylinder. The power thus exerted is sufficient to drain from the host pupa the last drop of its fluid contents without a change in position. A semi-diagrammatic sketch of these mouthparts, showing the limits of movement of the "plunger," is shown in Fig. 10.

The above type of mouth structure is quite unique among the parasitic Hymenoptera. Normally all stages are equipped with mandibles, though among ectoparasites feeding in the first two stages is largely by suctorial action. In the third, however, the mandibles are well developed and feeding is completed by devouring the tissues remaining, this often going so far as to include the entire chitinous derm of the host. *Schizaspidia* in this stage more nearly approaches the type of mouthparts borne by certain of the parasitic Diptera rather than those typical of the Hymenoptera.

The tracheal system, which could not be distinguished in the first two stages, is now propneustic, only one pair of spiracles being present and these placed laterally on the second thoracic division.

As feeding is completed within a few days after the second moult it is evident that the host pupa is not able to progress far in its development. No appreciable effect is produced by the presence of the first and second stages on the body, and consequently the pupa is of normal size and form in every respect. The third stage parasite larva however, drains the body so rapidly and thoroughly that no parasitized pupa is ever able to advance sufficiently to exhibit any traces of pigmentation in the eyes, the first organs to exhibit coloration in normal individuals.

In the nests of *C. herculeanus* sub-sp. *japonicus* at Koiwai during August and September may be found the cocoons of queens, males and major and minor workers. With the exception of the pupæ of the queens and major workers a single parasite is capable of consuming the entire body contents, and all that remains is the perfectly transparent, collapsed pupal envelope. In the case of the larger individuals only a portion of the body fluids are withdrawn, though death is nevertheless effected. Occasionally two larvæ may be found upon a single

host pupa, and in such instances their position is symmetrical with respect to the body of the host. Figure 8 shows a half-grown *Schizaspidia* larva in characteristic position upon a male pupa.

Pupal Stage (Plate XV, Fig. 9). The third and final larval ecdysis invariably takes place *in situ*, the remains of the host serving as a ventral cushion upon which the parasite pupa rests. Moulting is effected by a median dorsal split on the thorax, and the exuvium is then forced backwards over the body and is finally left between the caudal end of the pupa and the host remains. If the cocoon contains two parasite pupæ these always assume positions facing each other, and with the empty pupal skin of the host between them. In all such instances observed, both individuals were of the same sex.

The pupa is at first of an opaque, whitish color, and of the form represented in the figure. The characteristic intersegmental welts extend over three sides of the abdomen, and are slightly more pronounced on the caudal segments. The males may be readily distinguished by the longer antennal sheaths. Pigmentation sets in very shortly and the coloration and surface markings of the developing adults become clearly visible through the derm.

The Adult (Plate XIV).—The final transformation having taken place the adult remains within the cocoon for one, and occasionally two, days before emerging. This is then effected by the cutting away of a perfectly regular cap from the anterior end of the cocoon, the cut representing two-thirds of the circle and the cap remaining attached by one edge. Crawling out of the cocoon the parasites wander about the nest for a time and then escape into the open air. No assistance whatever is rendered by the ants of the colony at the time of emergence, nor are the parasites disturbed or interfered with in their movements.

In the laboratory several colonies were confined in artificial nests for observation as to the relations existing between the adult parasites and the ants themselves. Having no means of egress from the nest the parasites wandered aimlessly about and exhibited not the slightest interest in the larvæ or cocoons of the host. Occasionally they would be seized by workers and carried to the refuse heap, but without injury. Later, weakening through their fruitless wanderings, they are dismembered by the worker ants in exactly the same manner as decrepit

individuals of their own species. No instance was ever observed of workers feeding the parasites, and likewise repeated efforts to induce them to partake of honey or sugar solution resulted negatively. None were seen in the field visiting flowers or partaking of food in any manner, and it is therefore very probably that this species abstains wholly from feeding during its short adult life.

Dissections of adult females not yet emerged from the host cocoons revealed the fact that practically the entire quota of eggs in the ovarian tubes is already mature, and the gestative period is therefore reduced to a minimum. Counts of the fully-developed ovarian eggs yielded from slightly over nine hundred to eleven hundred, practically the number which is eventually deposited. Oviposition normally occurs on the day of emergence from the *Camponotus* nest.

Observations on emergence from several field colonies and on a considerable quantity of collected material gave the females predominance in numbers of two to one, and this is in accordance with the general ratio known to exist among the greater proportion of the Chalcidoid Hymenoptera.

Mating takes place almost immediately after the emergence of the female from the nest. On warm days, from 9:00 A. M. onwards, it was possible to observe swarms of males, numbering in some cases upwards of one hundred individuals, hovering in the air one or two feet above the entrance to the ant nests. The assembling of the males under these circumstances may be induced by the nest odor, though it is possible that the presence of the females themselves in the burrows can be detected. As the females first emerge into the light they are immediately pounced upon by the males, and mating takes place immediately and before the former are able to take to flight. Mating apparently occurs only once, as it has never been observed in places other than above mentioned, and laboratory experiments have failed to induce copulation except with newly emerged individuals.

The length of life of the adults of this species is extremely short, and under field conditions does not extend over more than three days following emergence from the nest. As oviposition occurs on the day of emergence, or the following day at the latest, the essential function of the individual is fulfilled and death takes place with little delay. In the laboratory,

under conditions inhibiting oviposition, females were kept alive for a maximum of five days.

No secondary parasites have thus far been found upon *Schizaspidia tenuicornis*. A considerable number of eggs are devoured or destroyed by an undetermined bud-moth on mulberry, while numerous adults fall prey to the large Asilid, (*Promachus yesonicus* Big.). However, the greatest loss among the adults is brought about by spiders of the family *Thomisidæ*, which abound upon the foliage of trees and shrubs, and which feed upon any of the smaller insects which they are able to catch. The female *Schizaspidia*, having begun oviposition, are unable to take wing quickly and are consequently very easily captured by the spiders. However, the combined loss from these natural enemies is not great.

Life Cycle.—During the season of 1921 the first adults were collected by sweeping on August 20th, though judging from the quantity of eggs later found in the buds they must have been present for some time previously. The maximum numerical abundance was attained about August 27th, and all adults had disappeared by September 15th. An examination of *Camponotus* nests at this time revealed the fact that all pupæ had developed and emerged, and only eggs and first stage larvæ were to be found. During the following season this locality was visited frequently in order to determine the date of first emergence. Two females were found ovipositing on August 14th, and their appearance in numbers from that date onwards was rapid. The greatest numbers were present on August 21st and 22nd, and none could be found after September 7th. This, then, also represents the period over which eggs are deposited.

In Korea emergence took place much earlier in the season, as ovipositing females were taken by J. L. King at Suigen during the latter part of June, 1922, the host in this case possibly being *C. herculeanus* sub-sp. *ligniperdus* var. *obscuripes* Mayr, as *C. herculeanus* sub-sp. *japonicus* does not mature sufficiently early to permit of the development of the parasite at this date.

At Jozankai, Hokkaido, Mr. K. Sato observed adults in numbers on August 5th, but not a single one could be found by the writer when he visited the same locality on August 31st.

In order to appreciate the significance of these varying times of emergence it is necessary to know certain facts in the

life-history of the host. At Koiwai *C. herculeanus* sub-sp. *japonicus* passes the winter in the egg and first larval stages, and by the middle of May all are in the second instar. In 1922 the first cocoons were found on July 11th, and a very few of these contained advanced first stage *Schizaspidia* larvæ. It is, of course, evident that no parasites can develop on this host until the pupal stage is reached, and consequently, by force of necessity, its advanced stages are limited strictly to the two months following the above mentioned date. The Korean *Camponotus* above mentioned attains the cocoon stage earlier in the season, and accordingly the development of the parasite is advanced to that extent. Jozankai, Hokkaido, being in a more northern latitude, has a much shorter summer season, and *Schizaspidia*, as well as most other insects, appears later and does not persist so long as at Koiwai.

Referring once again to the latter place, where observations were most complete, we have the eggs deposited in buds during the month following August 14th, and with the planidia within the eggs well developed twenty days later. In this condition they pass the winter and spring months. The first eggs hatch late in June and the larvæ crawl out on the twigs and foliage to await some means of transportation to the ant nest. Apparently solely by chance an occasional planidium succeeds in attaching itself to a worker ant as the latter wanders over the tree in search of food. Being transported in this way it reaches the nest and finally gains its place upon an ant larva. The first moult takes place before the host pupates, the second immediately after pupation, and the third less than one week later. Next comes the pupal stage of about six days, followed by a day of rest and finally emergence into the open air. The duration of the various stages of *S. tenuicornis* may therefore be given as follows:

Egg stage	approx. 11 months
First larval stage	20 days
Second larval stage	3 "
Third larval stage	4 "
Pupal stage	6 "
Adult, within the cocoon	1 "
Adult, outside the nest	2–3 "

This life-cycle contrasts very strikingly with that of such Chalcidoid Hymenoptera as are at present known. The egg stage in this super-family is normally of very short duration,

ranging from one to four days, and extended to seven to ten days in the case of *Perilampus*.

Habitat. The necessity for oviposition within the buds of various trees and shrubs has the effect of greatly restricting the general distribution of this parasite. Nests of *Camponotus* fifty or more yards distant from such trees were entirely free from attack. At Koiwai the district within which the parasite was extremely abundant comprised an area, about one hundred yards square, of waste land overgrown with weeds and bordered on one side by a grove of chestnut trees. In the center of the plot were two small mulberry trees, one of which has been referred to as containing such a great quantity of eggs. Nearby was one large birch tree, a few pines and miscellaneous shrubs. The elevation is approximately 1200 feet, and the climatic conditions somewhat comparable to those of the north central states, though the summer season is characterized by almost daily rains and with a constantly high atmospheric humidity.

General Considerations.—There are several points in the life-history of *S. tenuicornis*, as presented in the preceding pages, which give ground for much cogitation. The first of these is the early loss of such a great proportion of the eggs through the shedding in the spring of the bud scales to which they are attached. That the bud should open and develop is a normal sequence of events and it seems illogical that this should lead to the destruction and utter loss of the larger portion of these eggs. Those remaining in dead buds are often permanently imprisoned, while the remainder, after hatching and emerging from the buds, must depend solely upon chance for a means of transportation to the nest, and even when this is attained their very limited powers of locomotion render small the likelihood of the actual attainment of the position necessary to further development. It would seem, under these combined influences, that even the five-hundred-fold potential rate of increase would hardly be sufficient to compensate for all the adverse factors present.

An interpretation which was considered at one time was that of the egg-masses, as they fell from the trees during the month of May, being occasionally gathered up by the worker ants and stored in the nest with the brood, and their care by the ants over the following period of about two months. This theory is supported by the fact that the larva is not of the

true planidium type, having but limited powers of locomotion, and possibly requiring care and attention if it is to reach maturity. To test out this point a number of egg-masses were placed in an isolated corner of an artificial nest and the reactions of the ants observed. When first discovered the masses were examined carefully and finally carried into the inner chamber and placed among the larvæ. This appeared somewhat promising, but the following morning revealed them on the rubbish heap. Other egg-masses placed in the nest were discarded immediately. In the field none of these were ever found in the nests, though admittedly it would be easily possible to overlook them even were they present.

The main consideration which would seem to render the above interpretation untenable is the number of eggs in a single mass. In 1921 the average number per bud was 7200, and if only a single one of these masses were taken into a nest comprising several hundred larvæ the latter would certainly be annihilated. As a matter of fact, from the ten million or more eggs deposited that season within the limits of an area about one hundred yards square, less than one thousand adults were finally produced the following summer, a reduction in numbers of about ninety per cent as compared with the preceding season. The mortality in the early stages was therefore about 99.99 per cent. The highest degree of parasitism in any single nest observed during 1921 was 47 percent as compared with 16 percent for the following season. This result is diametrically opposed to that which we would have every right to expect were the above theory based upon fact.

It is conceivable that under different climatic conditions the egg-masses fallen from opening buds would contribute to the perpetuation of the species. As previously mentioned, the excessive humidity and daily rains prevalent at Koiwai during the summer season were conducive to extensive molding, and egg-masses placed in the open air were destroyed in a few days, the infection starting from the decaying bud-scales and quickly extending through the masses. In a dry climate it is possible that some of these egg-masses would fall in such a position as to be sheltered from direct sunlight and other detrimental influences, and be able to live and develop normally during the month or more preceding hatching. This having been accomplished, their opportunity to gain access to the ant nests would be equal to that of larvæ hatched from dead buds on the trees.

Another point in the life-history of this species which would seem to work to its disadvantage is the fact that the first larval ecdysis occurs prior to the attainment of the final position for development on the host pupa. While the planidium itself has no remarkable powers of locomotion, yet its capabilities in this respect are much greater than those of the second stage. It appears however, that the commencement of histolytic action preparatory to pupation provides the initial stimulus to development, and a moult consequently is forced prior to the transformation of the host larva to the pupal stage. Were the latter not enclosed within a cocoon it is very improbable that the parasite in its second stage would be able to regain connection with its host. For this reason it would seem necessary, in such species of ants as produce naked pupæ, for the Eucharid parasite to persist in the unfed planidium stage until attachment to the pupa is accomplished or, on the other hand, to complete its development before ecdysis actually takes place.

The remarkable habit of an insect parasitic upon the immature forms of ants in nests in the soil depositing its eggs in the buds of trees leads one to wonder as to the means by which such a habit could have been brought about. There are no parasitic groups among the Hymenoptera which are known to exhibit this marked departure from the normal, nor anything even more analogous to it, and we are thus left without a clew as to its origin. Were it suggested that the species had been originally a plant feeder and later developed its parasitic propensities, we are confronted by the fact that the entire family *Eucharidæ*, so far as known, is parasitic exclusively upon ants, and consequently parasitism must have been one of the earliest developments in the phylogeny of the race, and that the oviposition habit is a more recent departure. Any conjectures which we might make in this respect would be entirely in the realm of speculative entomology, and as such would be of little value.

Salient Features in the Biology of Schizaspidia tenuicornis.

1. The eggs are deposited en masse in the buds of various trees, and there pass approximately eleven months of the year.

2. Egg-masses in buds which develop normally in the spring are a total loss, only those in dead buds serving to perpetuate the species.

3. An average of slightly more than one thousand eggs is produced by each female, and these are all deposited within a period of not more than twenty minutes, or at the rate of about one per second.

4. The planidium, having emerged from the bud, gains access to the nest of *Camponotus* by attaching itself to a worker ant as the latter moves about the tree in search of food.

5. The second stage larva, rather than the first, effects the transfer from the cast larval skin to the pupa of the host.

Literature on the Biology of the Eucharidæ.

Considering the great extent to which ants and their associated insects have been studied in various parts of the world it seems remarkable that so very little has become known regarding the *Eucharidæ.* Host records are numerous, but further than this little is available. Forel (1890) first recorded a species of this family (*Eucharis myrmeciæ* Cameron) as parasitic upon ants, and gave a general description of the third stage larva. He reached the conclusion that *Eucharis* is parasitic upon the mature larvæ of *Myrmecia*, and this is doubtless true in the earlier stages, but it is very possible that transferrence to the pupa takes place just as in *Schizaspidia*.

The next, and last, contribution to our knowledge of this group was that by Dr. W. M. Wheeler (1907), wherein was presented an extended exposition of the biology of *Orasema viridis* Ashm., with notes on *O. coloradensis* Ashm., *O. wheeleri* Ashm., and *Pseudochalcura gibbosa* Provancher. As there are radical differences in the biology of *O. viridis* as presented by Dr. Wheeler, from that of *Schizaspidia*, it may be well to make a comparison of the two.

In general form the planidium of *Orasema* is very similar to that of *Schizaspidia*, though the latter is unique in having a heavy armature on the caudal segments instead of the usual unjointed stylets. The supposed banded second stage of *Orasema* is unquestionably an advanced first, and is similar to that of *Schizaspidia* and *Perilampus* (Smith 1912). The actual second stage is not mentioned or figured, unless it is his figure 16, though this has more the appearance and size of the early third, and resembles that of *Schizaspidia.* We now come to a rather surprising development in the biology of *Orasema* as compared with that of other Chalcidoid Hymenoptera, and this

is the intervention of two additional instars between the third larval and the pupa, namely, the pustulate fourth and the semipupa. These are entirely absent in *Schizaspidia*.

Orasema is said by Dr. Wheeler to emerge from the nest and mate in the open fields, and then to return and oviposit directly upon the mature larvæ and semipupæ. While the egg itself was never observed by him yet the probable manner and place of oviposition were discussed at some length. The need of a high potential rate of reproduction was attributed to the great danger of the egg becoming detached from the host. Smith (loc. cit.) in reviewing this portion of the paper, questioned this interpretation, and, assuming a parallelism in habit between *Orasema* and *Perilampus*, presented the hypothesis that the eggs are not laid in the nest at all, but upon flowers or other vegetation frequented by the parasite adults and worker ants; that the eggs hatch and the planidia in some manner attach themselves to these workers and are conveyed to the nest; and finally, that these planidia are at first endoparasitic, later emerging and completing their development as ectoparasites. It is possible that Mr. Smith's interpretation of this latter point may have been modified after his finding of *Perilampus chrysopæ* var. (1921) developing externally through all its larval stages upon *Chrysopa*.

Knowing now the life-history of *S. tenuicornis* in considerable detail it is possible to draw some conclusions as to the probable true state of affairs in the biology of *Orasema viridis*. Smith's assertion that oviposition occurs outside the nest is undoubtedly correct, though the likelihood of the eggs being placed upon flowers or foliage is small. In this connection it must be borne in mind that no trace of the parasite in any stage could be found in the *Pheidole* nests during the autumn, winter and early spring months. It is therefore probable that the winter is passed in the egg stage as in *Schizaspidia*, and such being the case they must be placed in some more sheltered position than is secured by indiscriminate oviposition upon foliage. Whatever occurs, the planidia upon hatching must be carried into the nests by the worker ants, as they are of a type very similar to that of *Schizaspidia* and probably possess no greater powers of locomotion. In case more than one generation per year is produced, and the appearance of adults in May makes this quite possible, it would necessitate a modification

in the manner and place of oviposition, yet this presents some difficulties. Might it be that the eggs of the spring brood of adults are placed in the seed-capsules of certain annuals rather than in the buds of trees?

In concluding this consideration of the biology of *Orasema viridis* it may be said that every known fact in its life-history points to a fundamental similarity to that of *Schizaspidia tenuicornis*.

Literature on the Biology of Perilampus.

In the family *Perilampidæ*, very closely allied taxonomically to the *Eucharidæ*, we find the only instances of oviposition entirely apart from the host that have heretofore been known to occur among the Chalcidoid Hymenoptera. Smith's contributions to the biology of the genus *Perilampus* constitute the only information available upon this extremely interesting group. One of its notable features is the great diversity shown to exist among the hosts, this being at present known to range over five different orders of insects, as contrasted with the single superfamily to which the *Eucharidæ* are apparently restricted.

The planidia of the species studied by Smith have far greater mobility than is evidenced by that of *Schizaspidia*, and this is made necessary by the habits and location of the hosts. Morphologically they are very similar, except that the former bears an extensive armature entirely lacking in *Schizaspidia*, but with a pair of unjointed stylets on the caudal segment in place of the five pairs of very heavy lanceolate spines on the four terminal segments of the latter. *Perilampus* is doubtless a more primitive form, and the greater specialization of *Schizaspidia* has rendered the above type of armature superfluous.

The habit of bud-oviposition herein recorded for *Schizaspidia* represents a considerable advance over the more or less indiscriminate leaf-oviposition of *Perilampus*. It may be asserted that certain of the *Leucospidæ* are at present in the incipient stages of development of a habit similar to that of the latter genus. According to Fabre (1886) the egg of *L. gigas* is placed within the cell of the mason-bee (*Chalicodoma muraria*) but not directly upon the host larva. The resulting first stage larva is of the planidium type and bears ventrally on each segment a pair of ambulatory setæ. The gap separating this departure

from the normal from that of *Perilampus* is not great, but neither gives a clew to the manner in which bud-oviposition, with its consequent prolongation of the egg stage to approximately eleven months, could have been brought about.

Oviposition Habits in Other Parasitic Groups.

Among the *Tachinidæ* the habit of leaf-oviposition has been demonstrated in the genus *Crossocosmia* by Sasaki (1887), in *Chætogædia* by Swezey (1908) and in *Blepharipa* by Townsend (1908). In other families, such as the *Bombylidæ*, oviposition is said to take place upon blossoms, etc., frequented by the hosts. Certain of the *Dexiidæ* scatter their eggs or larvæ promiscuously upon the surface of the soil, and the planidia burrow about in search of Scarabæid larvæ within which to develop. Several writers have observed the oviposition of *Oncodes* (fam. *Cyrtidæ*) upon twigs, and more recently King (1916) presented a detailed account of the biology of *Pterodontia flavipes*, parasitic upon Lycosid spiders. Oviposition takes place upon the trunks of trees, and the resulting planidium is very similar to that of *Perilampus*, both in form and habit. Modifications of the above oviposition habits are known to occur in other orders, such as the Coleoptera, and may even extend to the little-known group of parasitic Lepidoptera (fam. *Epipyropidæ*).

Among the parasitic Hymenoptera *Perilampus* has heretofore been the only group in which leaf-oviposition was known to occur. In an as yet unpublished paper Mr. Cho Teranishi, of this station, records the same habit in the family *Trigonalidæ*, and it is quite possible that this phenomenon will eventually prove to be much less rare than has thus far been supposed.

Descriptions.

Adults. (Plate XIV).

Female (Fig. 1).—Head nearly twice wider than deep. Lateral ocelli separated by half the distance between the eyes at the vertex. Mandibles (Fig. 1a) long, sickle-shaped, the left with one large tooth near the base, the right with two, which are subequal; two long spines on the inner edge near the base. Labrum palmate, with 8–11 digits, these produced at the tips. Antennæ 12-jointed, 2.2 mm. in length; the scape one-half longer than wide; pedicel as wide as long; first flagellar joint longest, one-third as wide at the tip as long; the second two-thirds as long as the first; those remaining of decreasing length, except the eighth, which is equal to the seventh, and the last, which is longer

than either of the preceding four. Ratio, 6:4:14:9:8.5:8:7.5:6.5:6:6: 5.5:7.

Fore wings 4.5 mm. in length, 1.6 mm. in width; veins in the ratio of 22:11:1:4; marginal vein obscured by a fuscous cloud, which broadens below. Alar expanse 11 mm. Hind-wings 2.7 mm. in length, .6 mm. in width; the submarginal vein extends to the hooks, which are four in number; posterior margin from the tip with a fringe of fine ciliæ.

Femora of fore-legs thickened and broadest at the middle; tibial spur with a tooth near the apex, which is lacking on the spurs of the mid- and hind-legs. Tarsal joints in the ratio of 12:4.5:3:2:8.

Abdomen visibly six-segmented, the first longer than the remaining five combined; all posterior margins emarginate medially. Petiole slightly shorter than the femora of the hind legs (10:11), somewhat dilated at the middle. Ovipositor barbed at the tip.

General color of the head and thorax metallic blue-green with bronze and purple reflections. Antennal scape, pedicel and basal half of first flagellar joint yellowish-brown, the remainder dark brown. Mandibles yellowish, with the inner margins black. Legs yellowish, except the coxæ, which are of the general body color, with the distal margin brownish; the last tarsal joint dark. Petiole testaceous, and broadly ringed with fuscous at the middle. First segment of the abdomen black, the remaining five testaceous except for a fuscous band at each posterior margin. In dried specimens the segments are largely retracted into the first, and the testaceous areas largely concealed.

Head with the transverse striations on the face, these turning upwards and curving around and between the eyes; vertex longitudinally, occiput transversely striate. Thorax generally foveate-punctate except the parapsides and episternum, which are smooth, with marginal punctuations. Outer face of the middle coxæ with large, shallow punctures. Petiole slightly rugose.

Length, 5.0–6.0 mm.

Male (Fig. 2).—Head slightly wider proportionally than in the female. Antennæ 12-jointed; length, 3.2 mm.; scape one and one-half times longer than wide; pedicel as wide as long; first six flagellar joints slightly swollen at the tips; tapering somewhat distad from the middle; first flagellar joint one-fifth as wide as long; ratio 7:4:23:18.5:17.5: 16:16:15:14:13:14.5.

Fore wings, length 4.0 mm., width, 1.5 mm.; alar expanse, 9.5 mm. Hind wings, length, 2.5 mm.; width, .5 mm.

Petiole longer than the hind femora (20:12). Abdomen of three visible segments, the first much the largest, and in dried specimens enclosing the second and third.

General color of the head and thorax metallic indigo-blue with bronze reflections. Petiole dark brown, with the base yellowish. First abdominal segment black, the second and third testaceous.

Punctuations of the thorax uniform with that of the female except the parapsides, which are shallowly, uniformly punctate instead of smooth. Petiole slightly rugose at the base.

Other characters as in the female.

Length, 4.5–5.5 mm.

Specimens were submitted to the U. S. National Museum for comparison with Ashmead's types of *S. tenuicornis*, and the determination verified by Mr. A. B. Gahan. The types, according to Gahan, comprise one female, lacking antennæ, and one male, the abdomen of which is missing. The original description of the female (N. Y. Ent. Soc., XII, 2, p. 151. June, 1904) apparently combines the characters of both sexes, as the antennæ described are certainly those of the male.

The species figured by Matsumura (Classification of Insects. Vol. II, p. 283, Pl. V, Tokyo, 1915) as *S. tenuicornis* is of some genus other than *Schizaspidia*.

Host.—*Camopnotus herculeanus* sub-sp. *japonicus* Mayr, and probably other members of the same genus. Such host relationships of other members of the genus *Schizaspidia* as are at present known indicate that it is restricted largely to this one group of ants.

Habitat.—Japan (northern Hondo and Hokkaido) and Korea.

Immature Forms.

(Plate XV).

The Egg (Fig. 11). Mature ovarian egg .125 mm. in length, .06 mm. in width, and with a stalk .23 mm. in length at the posterior end. This stalk is dilated at its distal end to three times the diameter at the middle.

After being laid, the main egg body is slightly increased in size, being .135 mm. in length, with the stalk measuring .21 mm. The latter is somewhat collapsed, due to a portion of the contents having been forced into the main body. Color white, and semitranslucent.

First Stage Larva (Figs. 2–5). Length fully extended, .1 mm.; width, .04 mm., and thickest at the thoracic regions, tapering sharply caudad. Segments nine in number, with no appreciable distinction between the thorax and abdomen. Head, .03 mm. in length, very deep brown in color, heavily chitinized, rounded at both ends, and tapering slightly cephalad. The heavily chitinized portion does not extend ventrad. The mouthparts comprise a membranous funnel terminating in a chitinized, transversely striate, ring. The mandibles (Fig. 12) are strong, heavily chitinized, with an excision at the base of the inner edge, and situated within the buccal cavity.

Body segments lightly, uniformly chitinized, pale amber in color, and tapering caudad, each fitting telescopically into the one preceding. The fifth (not counting the head), sixth and seventh each bear a pair of heavy spines ventrally near the lateral margin, these increasing the length on the successive segments. The terminal segment with two pairs of very heavy, lanceolate spines 10 μ in length.

The advanced first stage larva (Fig. 5) is .25 mm. in length and marked dorsally with six transverse bands, the first being widest and uniform throughout its length, the second and third slightly widened medially, and the remaining three somewhat linear. The two caudal segments show no distention. The elastic integument between the bands is uncolored.

Second Stage Larva (Fig. 6). Length, .6 mm., and with the nine segments distinct. The head is small, unchitinized, and placed ventrally beneath the first thoracic segment. The latter large and hemispherical, the second shorter, and the next five subequal, with the last longer and narrower. Mouthparts suctorial, with no evidence of mandibles. Color translucent, with the yellowish contents of the digestive tract clearly evident through the derm.

Third Stage Larva (Fig. 7). Immediately after the ecdysis 1.0 mm. in length, increasing to 6.0–7.0 mm. at the end of the stage. Possibly nine-segmented, the lines of demarcation indistinct at first and later entirely obliterated except for that between the head and thorax, between the first and second thoracic segments, the latter and the third apparently being fused, and a distinct division between the thorax and abdomen. The body therefore comprises only four main divisions; namely, the head, the first thoracic segment, the second and third combined, and the abdomen, the latter being much the largest. The caudal segment bears ventrally a conspicuous tubercle representing the anal orifice. Color opaque-white, with the derm thickly and uniformly set with minute raised dots, which produce a slightly roughened appearance.

The mouthparts (Fig. 10) are suctorial, comprising an oral opening at the base of a circular depression having a lightly chitinized rim, and within the buccal cavity a heavily chitinized and sharply pointed stylet, or "plunger." Immediately below the oral orifice are two bulbous prominences, doubtless homologous to the maxillæ, while above are two inconspicuous protuberances representing the antennæ.

Pupa (Fig. 9). Length, 5.0–8.0 mm., and 2.5–3.0 mm. in width at the posterior part of the abdomen, the widest point. Three conical protuberances are present dorsally on the head, these being superimposed over the developing ocelli. A number of similar prominences occur on the thorax. The abdomen bears five transverse intersegmental welts, which do not extend ventrally.

Color at first pure white, but later showing clearly the coloration and surface markings of the developing adult through the transparent pupal envelope.

The male is smaller and similar, but distinguished by the much longer antennal sheaths, these extending to the middle of the abdomen.

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EXPLANATION OF PLATES.

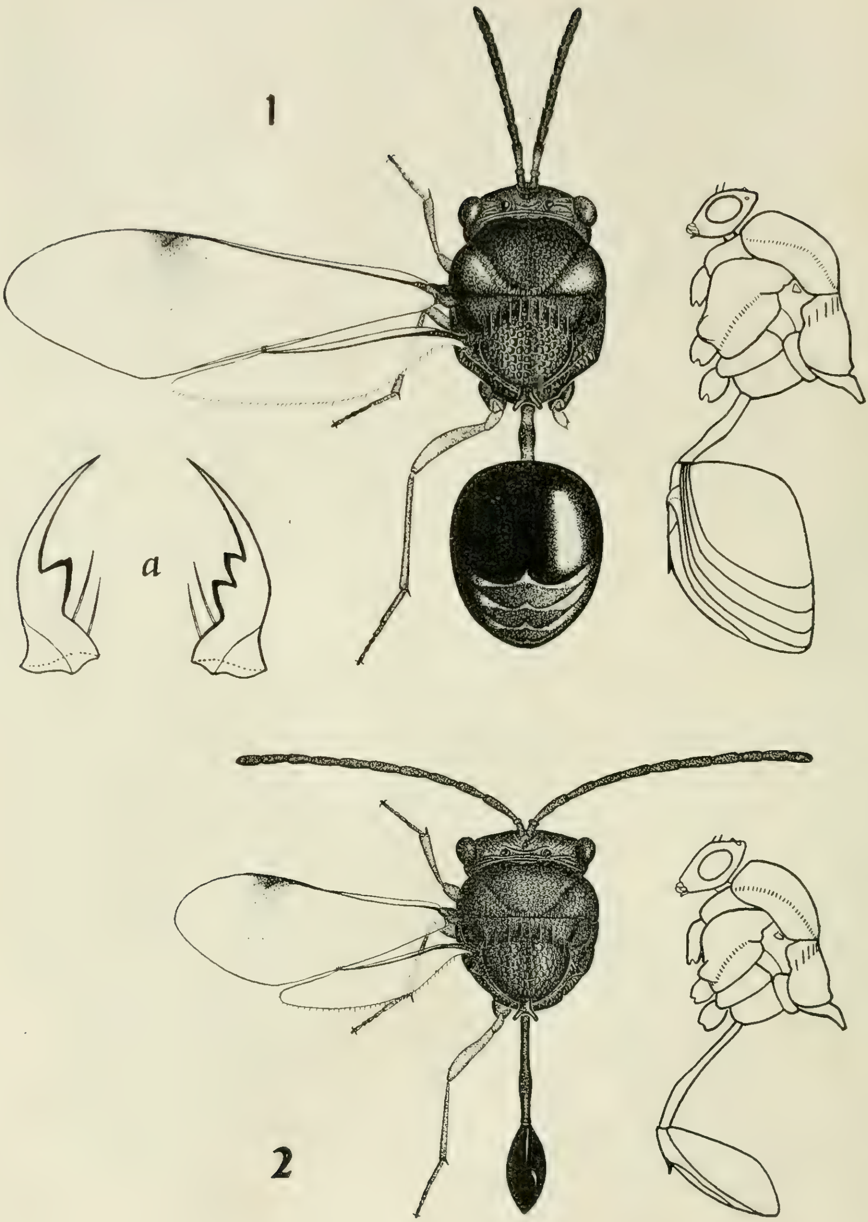
Schizaspidia tenuicornis Ashm.

Plate XIV.

Fig. 1. Adult female, dorsal view, with profile. (x 11). a. Mandibles.
Fig. 2. Adult male, dorsal view, with profile (x 11).

Plate XV.

Fig. 1. Mulberry bud with scales removed to show two egg-masses in situ. (x 20).
Fig. 2. First stage larva, lateral view. (x 500).
Fig. 3. First stage larva, dorsal view. (x 500).
Fig. 4. First stage larva, lateral view, with head retracted. (x 500).
Fig. 5. Advanced first stage larva, dorsal view. (x 200).
Fig. 6. Second stage larva, dorsal view. (x 85).
Fig. 7. Third stage larva, lateral view. (x 10).
Fig. 8. Third stage larva in situ on male pupa of *Camponotus*. (x 9).
Fig. 9. Female pupa, lateral view. (x 10).
Fig. 10. Sagittal section (diagrammatic) of the mouthparts of the third stage larva.
Fig. 11. Ovarian egg. (x 100).
Fig. 12. Mandibles of first stage larva.
Fig. 13. Three first stage larvæ adhering to the leg of a *Camponotus* worker. (x 50).



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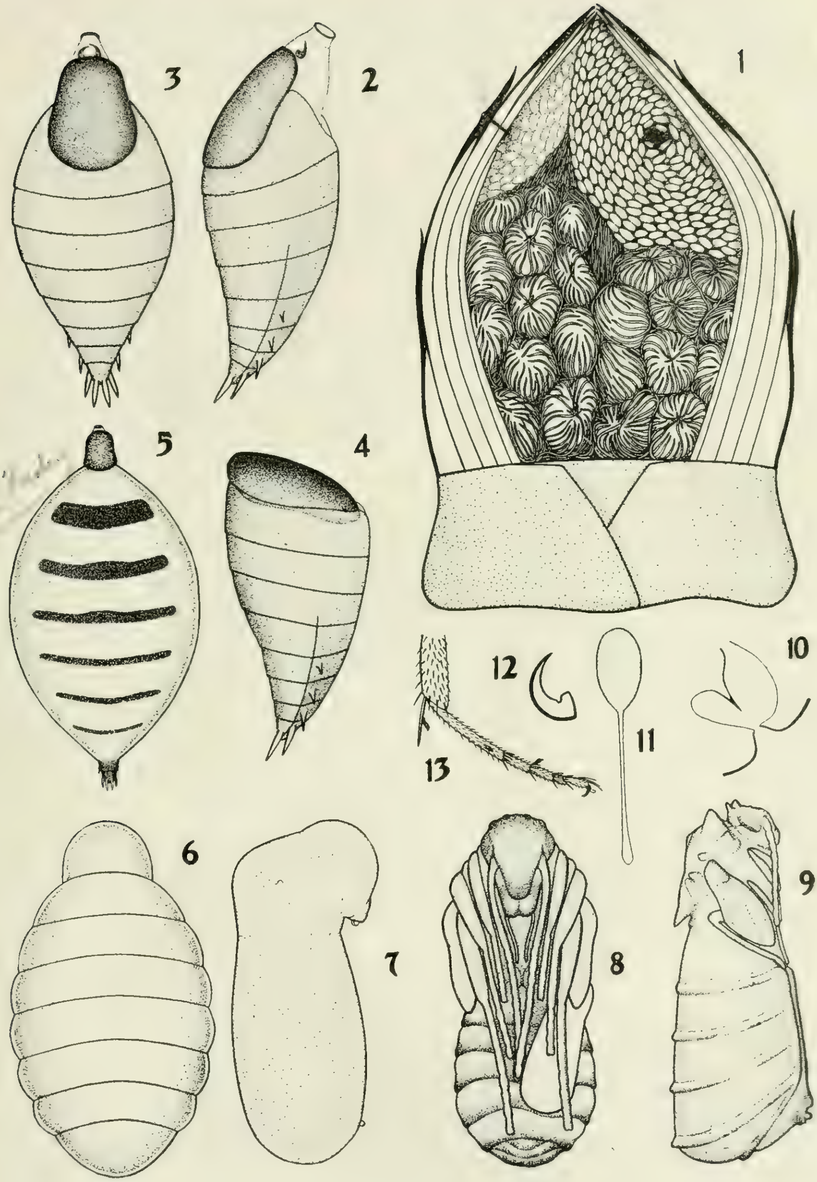


Curtis P. Clausen

THE BIOLOGY OF THE STAPHYLINIDÆ.

By Helen G. Mank.

INTRODUCTION.

This paper is an account of the life histories and habits of several Staphylinidæ. The adults of this large family are too well known to require any particular description. The active, elongate beetles, with their short elytra that leave exposed most of the abdominal segments, are found in a variety of places. Many are carrion feeders and are popularly associated with the Silphidæ by reason of their similar habits. They are also found in dung, in ants' nests, under the bark of trees, on the moist banks of streams and ponds, and in decaying animal or vegetable matter of all sorts.

The enormous number of species in this family has resulted in a considerable amount of work on the adult forms, but the study of the early stages of these beetles has been much neglected and in many cases these stages are entirely unknown. Probably the reason for this is because these insects have been considered of no marked economic importance. The larvæ are not unusual or beautiful enough to attract the casual observer to a closer investigation. As a consequence, collections of thousands of adults may not contain larvæ or pupæ of a single species. Published accounts of this family seldom include any special description of the larvæ or pupæ.

I wish to express my thanks to Prof. J. G. Needham, who directed the work of this paper, for his encouragement and help, and to Mr. H. C. Fall, who named the specimens under discussion.

HISTORICAL.

The comparatively few life histories hitherto studied have mostly been by three Frenchmen, Mulsant, Rey, and Xambeu. The other life histories that have been worked out, only some half dozen in all, are either unusually large and conspicuous types or they are forms that are parasitic on some insect pest and so, are of economic importance. A great proportion of the European forms described are not found in this country and therefore, the descriptions are not so useful to us.

The earliest account of the life history of forms in this group is a description of the larvæ of Staphylinus æneus, Staphylinus variabilis, and Xantholinus punctulatus in Bouchè's "*Naturgeshichte der Insecten*," published in Berlin in 1834. The descriptions are accompanied by drawings. The number and size of the teeth on the upper lip, a character that figures prominently in later papers, is hardly suggested in his plates.

The best accounts of the larvæ of the Staphylinidæ published are those by Schiodte, which appeared in 1864. His work includes many valuable drawings of both larvæ and pupæ, accompanied by brief but concise descriptions in Latin. The types he studied include two species of the genus Philonthus, five of Bledius, two of Quedius, and one each of Oxyporus, Ocypus, Xantholinus, Staphylinus, and Platystethus. Many of these belong to the larger forms in the family.

In 1875 Mulsant had published a description of Philonthus æneus, first described by Bouche as Staphylinus æneus.

In the section on Brevipennis in Mulsant and Rey's great work, "*Histoire Naturelle des Coléoptères de France*," 1877, the authors give scattered accounts of larvæ together with their descriptions of the adults. For instance, in the large genus Philonthus, there are descriptions of only eight larvæ and of these several of the species are not positively known. The plates illustrating the larvæ differentiate them wholly by the posterior end of the body.

Schaupp in the Bulletin of the Brooklyn Entomological Society for 1878, 1879, and 1880 published an account of the life history of Staphylinus vulpinus, Staphylinus maxillosus, and Listotrophus cingulatus. A few diagrams illustrate the text. Here again the forms chosen are among the largest in the family.

In 1886 Rey published an article giving a general description of Staphylinid larvæ followed by a more detailed account of a number of species. His work, together with that of Mulsant seems to have been the inspiration for Xambeu's articles later.

Certain of the Staphylinidæ are parasitic and their life history, therefore, has been of economic importance. A Cornell Bulletin for 1894 by Slingerland gives an account of Aleochara nitida, which is parasitic on the cabbage root maggot. A Minnesota Bulletin for 1908 mentions the same insect as an enemy of the cabbage root maggot.

Chapin ('15) gives a brief description of Xantholinus cephalus which was reared in plaster of paris casts.

The widest general view of the life histories in the family as a whole is found in several series of articles published by Capitaine Xambeu in *Le Naturaliste* and in *L'Éxchange*, 1907 to 1913. He not only describes a large number of species in genera representing all the sub-families; but in several genera, notably the genus Philonthus, he attempts to establish a basis of classification of the larvæ and suggests a possible method for determining the pupæ. Unlike the work of Wadsworth and others who have studied the parasitic Staphylinidæ from an economic standpoint Xambeu is interested mainly from the view of pure science. In both series of articles he introduces the paper by an account of the copulation, egg-laying, larvæ, and pupæ of the group as a whole. This is followed by a description of a large number of species. He makes his classification of the larvæ on the followed characters:

1. Upper lip.
2. Antennal lobes and terminations.
3. Length of caudal styles and pseuopode.

The second he considers the least valuable inasmuch as the segments of the antennæ and the other appendages are so easily broken off that many specimens could never be identified if that were the only basis. In each case he mentions the relative size and appearance of the caudal appendage but the real basis of classification he makes on the condition of the upper lip, or "lisiere frontale."

The most detailed as well as the most recent paper dealing with the life history of any of the Staphylinidæ is that of Wadsworth in the Journal of Economic Biology for June, 1915, in which he discusses the rove beetle parasitic on the cabbage root maggot. Other authors dealing with the same subject have described it as Aleochara nitida; Wadsworth, however, found all but one of some two dozen beetles that he raised to be Aleochara bilineata. He collected puparia of the cabbage fly every month in 1914, April and May excepted, and also in the early months of 1915. With a strong light the puparia containing parasites were detected. These were placed in glass topped boxes containing sterilized sand. Adult beetles emerged and were kept alive in captivity as long as three months. Living larvæ and the contents of puparia were given the beetles for

food, and the entire life cycle was observed in the laboratory. Detailed descriptions illustrated by plates are given of the ova larvæ, pupæ and imagoes.

MATERIAL.

The material for this paper was collected at Ithaca during the summer of 1919. The subject was suggested when a large number of rove beetles appeared in decaying vegetable matter in which flies were being bred. Plants of various kinds were ground up in a clover cutter and the material placed in cake tins. To induce flies to lay their eggs on this pulpy mass, it was baited with ground-up apple, hawthorn, grape or canteloupe and exposed to the air. The upper layers soon turned black, due to the oxidation of the broken plant cells, although in several cases the lower surfaces remained green indefinitely. Exposed to the air and to the changes of weather, some of the pans became wet and soggy, while those that were sheltered remained comparatively dry. Within a few days the mass was teeming with life. Dipterous larvæ of many kinds were most numerous but Coleoptera of several families were fairly abundant. Small Hydrophilidæ were found in the wettest of the pans; one or two of the Nitidulidæ were frequently found in the decaying fruit; but by far the commonest beetles were the Staphylinidæ. It is with these that this paper deals.

The first beetles were taken July 2 and others were collected at intervals of a few days until the latter part of August. Pans of vegetable substance in which they were found ranged all the way from nine days to two months old. The amount of decomposition in the plant material appeared to make no difference in the number of beetles, but the amount of moisture was of the greatest importance. The kind of plant used had some effect on the appearance of the beetles, although that again may have been mainly a question of moisture. The largest numbers of beetles were found in a combination of alder and touch-me-not, and in sweet clover. As to age, in one case nine days proved long enough to raise a swarm of fly larvæ and an abundance of rove beetles, and the oldest of the pans still had some insects. Where rain had fallen into the pans until they had become a wet, slimy mass, few beetles appeared although there was an abundance of fly larvæ. Mold, also, seemed an unfavorable environment. Rather dry material on the other hand, practically always showed a large number of Staphylinidæ.

The beetles, both larvæ and adults, were usually securely hidden in the material and when a pan of it was suddenly overturned they would go scampering away in all directions. Although their usual method of locomotion is walking, they can fly readily. They are extremely lively and elusive creatures but when once caught in the open, the larger ones especially, stand perfectly motionless with the flexible abdomen tipped over the back in a decidedly menacing attitude. They are not provided with any sting so their only means of defense is to emit a disagreeable odor, from the posterior end of the body. William Beebe, in an article describing army ants, says that these rove beetles were tolerated among the ants when any other living thing would have been destroyed immediately. A crippled ant hobbling along got out of the main line. Several beetles pounced upon it. A group of ants rushed out to join the conflict, whereupon the beetles raised their abdomens and ejected a drop of liquid and at that the ants were utterly confused.

Types found. A great number of the beetles captured or raised belong to the genus Philonthus. Philonthus brunneus was extremely common, and Philonthus longicornis was found frequently, while Philonthus cyannipennis appeared now and then. Specimens of Philonthus æneus and Philonthus lætulus were also taken. During August Belonuchus formosus came in great numbers, especially in the driest of the pans. Tachinus flavipennis and Tachinus pallipes (?) were common. Nearly every time that beetles were collected one or two specimens of Listotrophus cingulatus were found. One specimen of Siagonum americanum was taken. This is usually found under bark and as the pans were kept in a grove of hemlocks its presence was probably an accident.

Methods of raising. Both larvæ and adults were hardy and easily kept in small tin salve boxes which were half filled with moist sand. A bit of the disintegrating vegetable material from the pans was added to give the same general environment as that in which they had been found. This vegetable substance was full of Dipterous larvæ and mites and from time to time more larvæ were added. The Staphylinidæ were so easily raised that in about six weeks over twenty were reared from the larval to the adult stage in these little boxes.

Food. The strong curved mandibles of the larvæ bespeak a ferocity of habit that is well borne out by investigation. They

seem to be used for grasping their prey. I found no evidence that the larvæ actually eat their victims. Rather they seem to seize the fly larva and then suck out the juices. Often I noticed that the first incision was near the middle of the body of the fly larva. When food was put into the box the beetle larva ran around continuously but I could never induce the larva to eat while the box cover was off. Probably that was due to the light for the larvæ were always found far down in the midst of the vegetable substance away from the daylight. The larvæ are omnivorous in their habits. Larvæ of muscids and other Diptera were eaten readily. In two cases I fed them entirely on mites and they grew well. By accident two Staphylinid larvæ were left in the same box and one promptly devoured the other. In another instance a larva was put in a box with a pupa and the larva broke a hole in the covering and sucked out the juice. They thrive on a variety of food, both as to kind and as to amount. The amount of food that was definitely put in was no true estimate, however, for whenever vegetable matter was introduced it was full of minute forms of life.

LIFE HISTORY.

Egg Laying.—Xambeu gives an interesting account of the copulation and egg laying habits of these beetles. Reproduction usually occurs in the spring, rarely in autumn. Copulation may last for several hours or even a day. The eggs are laid under the dead body of some animal or in some other place already provided with food, that is, in decaying animal or vegetable matter or wherever Dipterous larvæ are to be found. The place is usually found by the olfactory sense of the female. She digs an oblong trench in the soil or other material with her anal segment and then deposits six to eight eggs in it, one at a time, and covers it all with earth or with food. The egg is so large in comparison with the size of the ovipositor that the act of egg laying is exhausting and the female usually dies soon afterward.

The egg is oval, a yellowish white, finely striated longitudinally. After eight to ten days it opens lengthwise.

Larvæ.—Larvæ were never found as abundantly as were adults among the vegetable mass. In fact, I often found adults without a sign of the larvæ. These were usually to be found in dry substances and when one appeared often a number were found. These varied from very young ones, hardly more than a millimeter in length to an occasional giant an inch long. The larva of most of the forms studied was about 7 mms. long. The general shape of the larva is slender and tapering. They are active creatures, constantly crawling here and there in search of food among the stuff in which they live. The head is

subquadrate, reddish brown in color, and heavily chitinized. The antennæ arise at the base of the mandibles and are four-jointed. The first segment is short and broad; the second, long; the third, long with a supplementary joint on the inner side; the fourth, short with a brush of stiff hairs at the tip. The mandibles are chitinized, strong, and sickle-shaped. The first joint of the maxillæ is short and broad, the second is more slender and twice as long, with a small immovable lobe on the inner margin. The palpus is made up of five small segments. The mentum is short, the ligula, shorter, the palpi are small and vary in number. There are several long hairs on both the antennæ and the maxillæ and these hairs and even the lobes themselves are easily broken off.

Ocelli.—In some families the number and position of the ocelli are so constant that they may be used to distinguish the family from its near relatives. In Schaupp's description of the larvæ of this family, he distinguishes them from the Carabidæ by stating that the Staphylinidæ have one claw and four ocelli, while the Carabidæ have two claws and six ocelli. In MacGillivray's key to the Coleopterous larvæ he places Staphylinidæ under the head of "ocelli usually 4." In the larvæ that I have examined I found that there were usually 4 ocelli, three together and one a little posterior, but in one species, *Tachinus flavipennis*, I found six distinct ocelli in two rows, four in the anterior and two in the posterior row.

In examining Xambeu's published descriptions I found the greatest divergence in the number and appearance of the ocelli in this family. Not only is there no constancy in the family as a whole, but even in a single genus among closely related forms there is all manner of variation in the ocelli. The number ranges all the way from one to six. Some are so nearly like the color of the background that they are indistinguishable from it while many have conspicuous black or brown spots. Sometimes several form a confused group so that there seems to be but a single spot. In location they are placed at the base of the mandibles or the antennæ. Often when four or more are present they seem to be in two groups. Three close together and one posterior is a common arrangement. When there are but three they often form a triangle. Five may be grouped as four and one or three and two. Six may be grouped as four and two or three and three.

It is quite natural for the authors mentioned above to give the number as four without further comment since the forms described were all among the Staphylinidæ that ordinarily do have four ocelli.

The following table compiled from Xambeu's descriptions gives some idea of the amount of variation among the different forms:

Table Showing Number of Ocelli in the Larvæ.

Atheta testaceipes	One dark point at base of mandibles.
Atheta crelata	Five, four above and one below.
Atheta Pertyi	One point.
Falagria amicula	Group of confused black points.
Leptusa solifuga	Three reddish spots in triangle.
Leptusa laticornis	Ocelli very small in form of cross.
Placusa complanata	Black elliptical spot in each cheek.
Cyphena curtuta	Large black spot.
Gyrophæna affinis	Small black spot.
Gyrophæna manea	Large black spot.
Phytosus nigriventus	Small triangular spot.
Oligota flavicornis	Small black spot.
Conurus littoreus	Six, four above and two below.
Tachinus rufipes	Five, four in arc, one behind.
Tachinus laticollis	Six, four in front, two behind.
Tachinus subterraneus	Six, four in one line, two in other.
Tachyporus brunneus	Five, three and two.
Bolitobius exoletus	Confused group.
Velleius dilatatus	Three large black spots.
Staphylinides	Four in line or in circle around protuberance.
Othius myrmecophilus	One large point.
Baptolinus affinis	Three in triangle.
Midolius collaris	Shining elliptical spot.
Xantholinus punctulatus	Four or five points at posterior angle of head.
Xanthelinus tricolor	Brown spot.
Lathrobium augustatum	Confused group at base of antennæ.
Lathrobium mutipunctum	Three or four.
Medum aveyronnensis	Five, three and two.
Pæderus tempestivus	Six, three and three.
Platystethus cornutus	Striking black spot.
Platystethus spinosus	Not apparent.
Platystethus nitens	Intense black spot.
Oxytelus picens	Black point.
Oxytelus sculptus	Large rounded point.
Bledius tricornis	Three in semicircle.
Ancyrophorus flexuosus	Three in triangle.
Ancyrophorus omalinus	Three in triangle.
Syntomium æneum	Confused with background.
Micralmia marinum	Five, four and one.
Omalium	Five in arc of circle.
Antholium	One large spot.
Proteinus ovalis	Three in semiarc.
Proteinus limbatus	One shining black spot.
Megarthrus affinis	One point.

Upper Lip.—The larvæ of the Staphylinidæ have a peculiar upper lip with a toothed margin. The homology of this region has not always been clear. Sharp says that the Staphylinidæ have no labrum. Schiodte calls this region the epistoma. Kemner describes it as frontale and clypeus. Wadsworth names it the upper lip. Xambeu calls it the "lisiere frontale," or frontal border. On the basis of the number and character of the teeth on the margin he classifies a large number of the larvæ that he describes. Of nineteen species of Philonthus that he

describes, all but one readily fall into this system of classification and he says that many other genera would be as easily distinguished by this character. In his later and more extensive papers in *L'Échange*, it is interesting to see how far this rule may be applied. This character cannot be used in the case of the Aleocharinæ, Tachyporinæ, Xantholindes, Paederinæ, Oxytelinæ, Oxyporinæ and Omaliens, but it is useful among Philonthus, Quedius and Staphylinus, in fact among most of the Staphylininæ. Where it is applicable it is most convenient, since it is constant, easily seen, easily described, and unlikely to be broken off or obliterated in any way.

Pseudopode.—One of the characteristic features of the Staphylinidæ is the cylindrical organ at the posterior end of the body. It is called "pusher" by Ganglebauer and "pseudopode" by Xambeu. "Pusher" is an excellent descriptive term, for the larva uses it as such whenever it walks. It is in use most of the time apparently, for the little creature is moving all the time from the minute it is out of the egg until a day or two before pupation. The pseudopode is a fleshy, cylindrical organ, as long or a little longer than the first segment of the anal style. The two anal styles flank the pseudopode and are set at an angle to it. They are biarticulate. The second segment is very slender and is terminated by a bristle.

Molting.—Xambeu says that there are three molts at least. I found two in Philonthus cyannipennis, but very likely the larva had molted once before I captured it. Philonthus cyannipennis and Listotrophus cingulatus both leave their skins, but with the smaller forms no trace of the larval skin is left except when it goes into the pupal stage. Xambeu says that they eat their skins. All these transformations occur at night.

Pupæ.—Pupæ were seldom found in the pans of vegetable substance, but larvæ placed in the salve boxes readily transformed. For a day or two previous the larva was very quiet and neither moved nor ate. Then the larval skin would break down the back and morning would find the shining, yellowish brown pupa, thoroughly chitinized, in the midst of a little nest in the damp sand. In every case the transformation took place at night. Occasionally the larval skin did not break far enough for the creature to emerge and the larva died then and there. Kellogg says, "The pupæ of some species are enclosed in a sort of exudation that dries into a firm protecting coating rather like the horny cuticle of a Lepidopterous chrysalid." I found this in Tachinus flavipennis, but in no other.

The pupa rests on the dorsal side with the head curved downward. On each side is a piece of chitin in the form of a coil. On the border between the head and the first thoracic segment is a fringe of hairs varying in number according to the species. This makes one of the best ways of classifying different species by the pupæ. The only difficulty is that these hairs are readily broken off. The dorsal side is somewhat depressed with a large spiracle visible in the anterior corner of the first abdominal segment and a small one in the anterior corner of the next

three segments. The body tapers to the last segment, which terminates in two anal styles which are biarticulate and end in a spine. Stiff hairs project laterally from the abdominal segments. These I have found to be an excellent means of distinguishing the pupæ of different species. For instance, the pupæ of Philonthus brunneus and of Philonthus longicornis are very similar in appearance, but the former has two divergent spines on the lateral margin of four abdominal segments and one on the next two, while the latter has a single spine on each of the six abdominal segments. The length of time that the pupal stage lasted depended on the weather as well as on the species, but usually it lasted from ten to twelve days. A day or two before the emergence of the adult, the pupa turned a mahogany brown. Then in the night the pupal skin broke and the adult appeared. At first it was but partially colored, but in a few hours it assumed its normal appearance.

SUMMARY.

In a period of about two months I raised twenty beetles from larvæ. In one instance the beetle was reared from the egg. The list includes eight Philonthus brunneus, (one of these was from the egg); four, Philonthus longicornis; one, Philonthus cyannipennis; one, Tachinus flavipennis; and five Belonuchus formosis. Several larvæ larger than any of these were found. One formed a pupa but died before it emerged. Probably this was Listotrophus cingulatus. The reasons for this belief are as follows: This is the only species of adult larger than Philonthus cyannipennis that was found, the larva is similar to the description of Listotrophus by Schaupp, and the pupa resembles the pupa of Listotrophus in the LeConte collection at Harvard.

Time. The length of time required for each stage of the life cycle is somewhat variable. An egg of Philonthus brunneus found August 9 hatched in four days. The larval stage lasted eleven days and the pupal stage thirteen days. In other cases the pupal stage lasted seven, ten, eleven, and twelve days. The pupal stage of *Belonuchus formosus* lasted nine and twelve days. The pupal stage of *Philonthus longicornis* was six, seven, nine and ten days. *Philonthus cyannipennis* took nine days.

TABLE OF STAPHYLINIDÆ RAISED.

Name	Larva Found	Becomes Quiet	Forms Pupa	Pupa Turns Dark	Emerges As Adult
Philonthus longicornis	July 10	....	July 22	July 27	July 29
Philonthus longicornis	July 18	July 25	July 27	July 30	Aug. 2
Philonthus longicornis	July 18	July 25	July 27	Aug. 3	Aug. 5
Philonthus longicornis	July 25	July 29	July 30	Aug. 6	Aug. 9
Philonthus brunneus— Egg found Aug. 9; Egg hatched Aug. 13	....	....	Aug. 24	....	Sept. 6
Philonthus brunneus	July 28	Aug. 1	Aug. 2	Aug. 11	Aug. 12
Philonthus brunneus	July 28	....	Aug. 1	....	Aug. 11
Philonthus brunneus	July 28	....	July 30	Aug. 11	Aug. 12
Philonthus brunneus	July 16	July 22	July 23	July 29	July 30
Philonthus brunneus	Aug. 9	Aug. 13	Aug. 24	....	Sept. 6
Philonthus brunneus	Aug. 16	....	Aug. 23	Aug. 29	Sept. 2
Philonthus brunneus	Aug. 11	....	Aug. 13	....	Aug. 25
Philonthus cyannipennis	July 18	skin shed July 21	July 28	Aug. 5	Aug. 6
Belonuchus formosus	Aug. 9	....	Aug. 20	....	Sept. 1
Belonuchus formosus	Aug. 9	Aug. 11	Aug. 15	Aug. 23	Aug. 24
Belonuchus formosus	Aug. 12	....	Aug. 23	....	Sept. 1
Tachinus flavipennis	Aug. 13	....	Aug. 18	....	Aug. 24

Philonthus brunneus Grav. (Fig. I.)

Egg, (1 mm. in length). The egg was found August 9th in a rather dry mass of ground alder and touch-me-not. It is white in color and oval in shape, somewhat flattened at the ends. The surface is sculptured by dots thickly set in lengthwise striations. The egg breaks along these lines.

Larva.—The larva appeared four days later, August 13th. It is about 2.5 mm. in length. The head is reddish yellow and chitinized. The rest of the body is soft and white. It is very active and readily eats mites or small Dipterous larvæ. It grew rapidly and attained its full size in a few days. According to Xambeu it probably molts three times, but I was unable to discover any traces of these larval skins. Xambeu says that they eat the larval skin immediately. The full grown larva is a slender, active creature about 7 mm. long.

Head.—The subquadrate head is reddish brown and heavily chitinized. The mandibles are slender and sickle-shaped. The antennæ arise from the base of the mandibles. They are four-jointed. The first segment is short and broad; the second is longer and more slender; the third is similar to the second, but bulges toward the tip, where it has a small immovable joint on the inner side; the fourth segment is short and is tipped by several short hairs surrounded by three or four longer ones. The upper lip has seven teeth. The median one is very small. The first lateral pair is long, the next two lateral ones are considerably shorter and between them is a long hair arising from a distinct papilla.

Small hairs are seen between the other teeth. The first joint of the maxilla is short and broad, the second somewhat more slender and twice as long, with an additional lobe at the inner margin. The palpus is made up of five small segments. The labial palps have three segments.

Thorax.—The dorsal side of the thorax is covered with a reddish brown plate of chitin with several hairs scattered along its margin. The meso- and meta-thorax are half as long and are similar in appearance. The ventral side is white without any sign of chitin except a small triangular piece anterior to and between the first pair of legs.

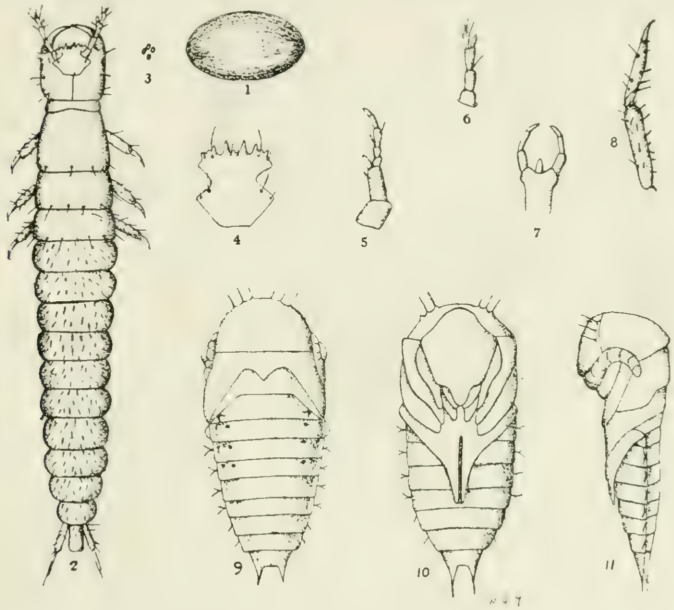


FIGURE I.

Fig. I. *Philonthus brunneus* Grav. 1, Egg. 2, Larva, dorsal view. 3, Ocelli. 4, Upper lip. 5, Maxilla. 6, Antenna. 7, Labium. 8, Leg. 9, Pupa, dorsal view. 10, Pupa, ventral view. 11, Pupa, lateral view.

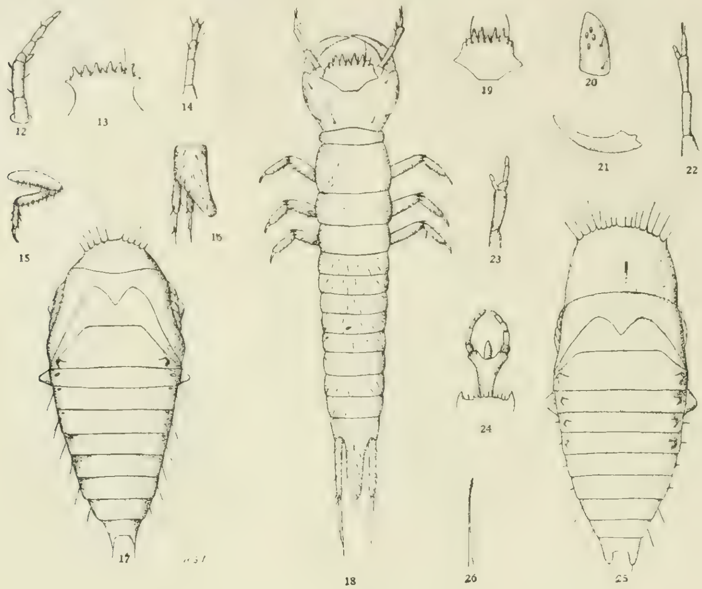
Abdomen.—The abdomen is a dirty white with short brown hairs scattered over its surface. It tapers toward the posterior end. The pseudopode is moderately long and thick. The anal styles are made up of two segments. The second is shorter than the first and is very slender. It is terminated by a long bristle. The styles are widely divergent. Both styles and pseudopode have hairs scattered over them.

Legs.—Small spines are scattered over the surface of the legs. The single claw on the tarsus is characteristic of all of the Staphylinidæ and is an easy way of distinguishing this family from the Carabidæ.

Pupa.—The pupa is 3.5 mm. long. There is a fringe of six hairs, three on each side at the anterior edge of the thorax. On the abdomen there are two divergent spines on the lateral margin of four segments and a single one on the last two segments before the terminal one, which ends in two projections, each tipped with a bristle.

Philonthus longicornis Steph. (Fig. II.)

Larva.—The larva of Philonthus longicornis is similar to that of Philonthus brunneus. In fact, it is difficult to find characteristics distinct enough to differentiate the two. The upper lip is the best character to use in this case. Both have an upper lip with seven teeth; in both the median one is very small and the first lateral pair is long, but in Philonthus longicornis the next lateral pair is practically the same size as the first, while in Philonthus brunneus it is distinctly smaller than the first lateral pair.



FIGURES II AND III.

Fig. II. *Philonthus longicornis* Steph. 12, Maxilla. 13, Upper lip. 14, Antenna. 15, Leg. 16, Pseudopode and anal styles. 17, Pupa, dorsal view.

Fig. III. *Philonthus cyannipennis* Fab. 18, Larva, dorsal view. 19, Upper lip. 20, Side of head showing ocelli. 21, Mandible. 22, Antenna. 23, Maxilla. 24, Labium. 25, Pupa, dorsal view. 26, Hair, from anterior margin of thorax.

Pupa.—The pupæ of Philonthus longicornis and Philonthus brunneus are easily distinguished. The former is some two mm. longer than the latter. Still more easily recognized are the hairs on the anterior margin of the thorax. On Philonthus longicornis there are five on each side, while on Philonthus brunneus there are three on each side. The bristles on the lateral margin of the abdominal segments are also distinctive. In Philonthus longicornis there are six bristles on each side, one on each segment. In Philonthus brunneus there are two divergent bristles on four segments and a single one on the next two segments.

Philonthus cyannipennis Fab. (Fig. III.)

Larva.—(Length 13 mm., width 2 mm.) The body is elongate and flattened.

Head.—The head is reddish and heavily chitinized. It is quadrate, wider than the thorax and with the posterior angles rounded. The mandibles are simple and sickle-shaped. The upper lip has five distinct teeth. The median one is small. The two lateral pairs are large. There is a short hair on either side of the median tooth and also between the lateral teeth and a long hair just beyond the lateral teeth. The lateral margin of the upper lip has two irregular projections not distinct enough to be called teeth. A short hair is found between these two projections. The antennæ are four-jointed. The first segment is short and broad. The second is three times as long and narrower. The third is twice as long as the first and narrow, with an additional lobe at the inner side. There are several long hairs near the tip. The fourth segment is short, ending in a group of long hairs. The first segment of the maxilla is short and conical. The second is long, with a short lobe of two immovable joints. The palpus is three-jointed. The ocelli are four, in two groups, three in one and one in the other. The labial palps have three segments.

Thorax.—The prothorax is dark reddish brown, slightly wider toward the posterior edge. The meso- and meta-thorax are equal in size, one-half as long as the prothorax and a lighter brown.

Abdomen.—The abdomen is a dirty white with short brown hairs irregularly scattered over it. The last segments become slightly longer. The pseudopode is barrel-shaped and longer than the last abdominal segment. The anal styles are set at an angle of 40° to the pseudopode and are set with many hairs. The second segment is long and slender and ends in a long bristle.

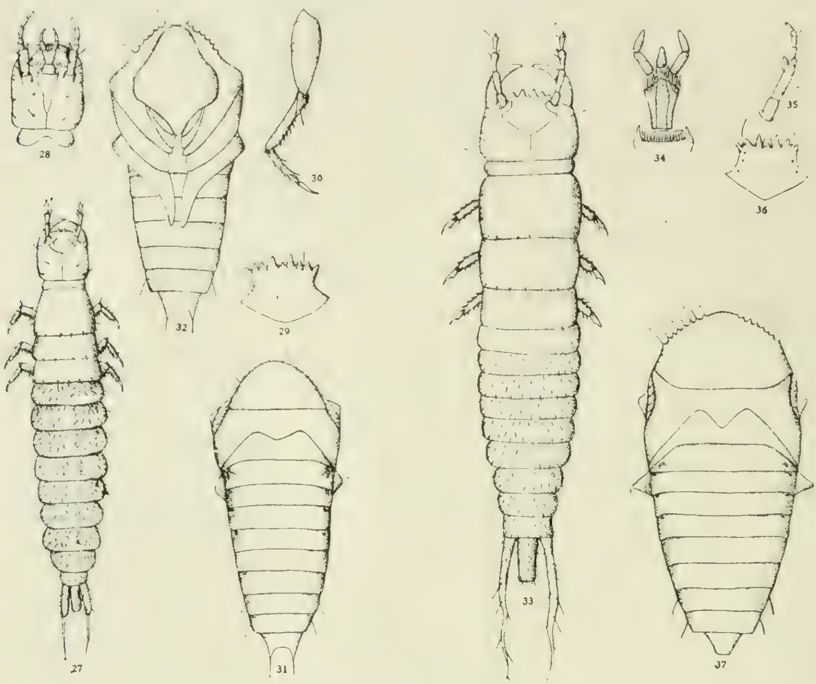
Pupa.—The pupa is in a case of yellowish brown chitin. There is a fringe of hairs, eight on each side, at the anterior margin of the thorax. There are six spines, four short and two long, on the lateral margin of the abdominal segments. The last abdominal segment ends in two more or less rounded projections terminating in a bristle.

Belonuchus formosus Grav. (Fig. IV.)

Larva.—(Length 7 mm., width 1.5 mm.) The body is elongate, slender and tapering. The head and thorax are reddish brown, the abdomen is a dirty white with gray patches on each segment. The gray region is divided by a broad median line. Short brown hairs are scattered over the body.

Head.—The head is quadrate, slightly broader than the thorax. The upper lip is nine toothed. The median tooth is very small, the first lateral pair is large, the next three lateral pairs are small. There are hairs between the teeth, all short except those between the second and third from the end, which are long. The mandibles are simple and

curved. The first segment of the maxilla is short and broad, the second is long and tapers toward the tip, with a small immovable joint at the inner edge. The palpus is four-jointed. The antennæ are four-jointed. The first segment is short and broad; the second is longer and slender; the third is the same length as the second and slightly broader, with a small lobe on the inner side; the fourth is short and slender, with two bristles surrounding a tuft of short hairs. There are four ocelli, three in one group and one somewhat posterior.



FIGURES IV ANE V.

Fig. IV. *Belonuchus formosus* Grav. 27, Larva, dorsal view. 28, Head, ventral view. 29, Upper lip. 30, Leg. 31, Pupa, dorsal view. 32, Pupa, ventral view.

Fig. V. *Listotrophus cingulatus* (?). 33, Larva, dorsal view. 34, Labium. 35, Maxilla. 36, Upper lip. 37, Pupa, dorsal view.

Pupa.—The pupa is a yellowish brown. There is a fringe of hairs, seven on each side, at the anterior edge of the thorax. There are lateral spines on the second and third last abdominal segments, each of which has one long spine on the lateral margin. The terminal segment has two projections ending in a bristle.

Tachinus flavipennis Dej. Fig. VI.)

Larva.—(Length, 7 mm.) This larva is linear, slightly depressed, and not as slender as most of the other forms studied. Instead of tapering toward the end of the body, there is a slight widening toward the posterior region. The color is distinctly brown. Each abdominal segment has two chitinized plates, one on the dorsal and one on the ventral side.

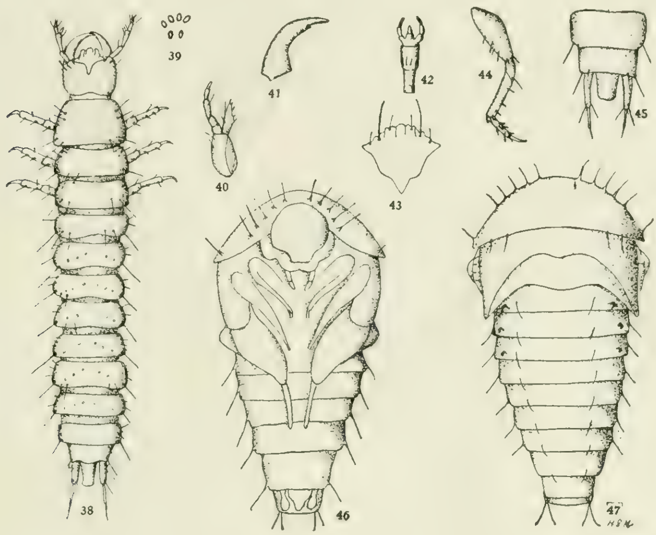


FIGURE VI.

Fig. VI. *Tachinus flavipennis* Dej. 38, Larva, dorsal view. 39, Ocelli. 40, Maxilla. 41, Mandible. 42, Labium. 43, Upper lip. 44, Leg. 45, Pseudopode and cerci. 46, Pupa, ventral view. 47, Pupa, dorsal view.

Head.—The head is oval and somewhat narrower than the thorax. The upper lip is without distinct teeth, but is divided into three regions. There are six ocelli arranged in two groups, four close together and the other two more separate and posterior to the group of four. The antennæ are made up of the following segments: The first segment is short and broad, the second is twice as long and somewhat more slender, the third is the same length as the second, becoming broader toward the tip and with an additional lobe on the inner side. There are two long hairs near the tip of this segment. The fourth segment is small and short with one long hair. The maxillæ are entirely different from those of Philonthus. There is a basal piece made up of two sclerites. Attached to this region are two parts. The inner one is rectangular, with a toothed edge like a comb on the inner side. The maxillary palpus makes the other region and consists of five slender segments. In the mentum and ligula is a squarish basal piece. The ligula is narrow at the base, broadens suddenly, and ends in a prolongation. The palpi are two-jointed.

Pupa.—The pupa is very different from any of the other Staphylinidæ under consideration. Instead of being thoroughly chitinized, it is covered with a soft substance which is pure white at first. When the box was uncovered, the light stimulus made it active and the posterior end would wave back and forth. Under the electric light the light or heat, or perhaps both, made it even more active than it was in the sunlight. This power of movement continued throughout the pupal period to some extent. As the days passed the pupa became a grayish white and the legs showed as dark patches through the thin covering. This covering when examined seemed silvery and glistening like fish scales. There is a fringe of twelve hairs, six on each side, at the anterior margin of the thorax. There is one bristle arising from the lateral margin of each abdominal segment and a double row of hairs nearer the center. The terminal segment is blunt and has four bristles.

CONCLUSION.

From these descriptions of a few larvæ and pupæ some generalizations are evident:

1. Staphylinidæ may be distinguished from the Carabidæ which they resemble in a general way by the following characters:

Carabidæ—	Staphylinidæ—
Inarticulate caudal styles	Biarticulate caudal styles
Two prongs on tarsus	Single prong on tarsus

2. All the Staphylinidæ are of the same general appearance and structure although there is considerable difference in size.

In the types studied, one belongs to the genus Tachinus, in the subfamily Tachyporinæ. The other five belong to the subfamily Staphylininæ in the following genera: one Listotrophus, one Belonuchus, and three Philonthus. Naturally Tachinus differs from the others in many respects. First, the shape of the larval body grows wider toward the end instead of tapering. Second, the chitinization of the abdominal segments differs, there being in Tachinus distinct chitinized plates on each dorsal and ventral abdominal segment. Third, the maxillæ are a distinctly different type as shown in the drawings. Fourth, the upper lip is not toothed.

There is a marked similarity among the Staphylininæ. The head and thorax are reddish brown and heavily chitinized. The abdomen is a dirty white. According to Xambeu there are three distinguishing characters, viz.:

1. Upper lip.
2. Antennæ and other appendages.
3. Pseudopode and anal styles.

I agree with him in thinking that the first is the most constant and definite character. The number and size of teeth are distinctive in each type studied. The antennæ and the maxillæ are so easily broken off that I should hardly call them good characters to use. The number of segments in the labial palpi, is variable. The pseudopode and anal styles or cerci vary somewhat in size but here again the differences are slight and hard to describe. One other character not noted by Xambeu I have found useful in distinguishing genera. That is the shape of the suture between the upper lip and the front. Notice the drawings of Belonuchus and Philonthus and at a glance the difference is apparent.

The characters of the pupæ are more distinctive than those of the larvæ. Tachinus has an entirely different covering of a scaly, silvery substance. The Staphylininæ all have a covering of yellowish brown chitin and although differing in size, have the same general shape and appearance. They do vary, however, in two respects. First, the number of hairs on the anterior margin of the thorax differs with each species studied. Second, the form and number of the bristles on the lateral margin of the abdominal segments varies with the species. By using these two characters it is comparatively easy to name the species from the pupæ.

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THE LIFE HISTORY AND HABITS OF BICYRTES QUADRIFASCIATA SAY.

(Order Hymenoptera, Family Bembicidæ).

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The wasp which is the subject of this paper is a member of the family *Bembicidæ*, a family of solitary digger wasps. The family *Bembicidæ* is divided into two tribes, the *Stizini* and the *Bembicini*, to the latter of which *Bicyrtes quadrifasciata* belongs. Wasps of this tribe are of a large robust striking appearance. The ground color of these wasps is black, on top of which lies stripes or spots of light yellow or yellow. The wings may be hyaline or infuscated and the body may be thickly pilose or more or less free from this. According to Parker: "The most prominent characters distinguishing the *Bembicine* wasps are the non-folded wings lying flat on the back, the three closed cubital cells of the anterior wings, of which cells the second receives both discoidal cross veins, the absence of the prepectus, the prominently exserted labrum and the lack of developed ocelli." The individuals are males and females. The female constructs her nest alone in sandy areas and provides for her offspring; nests are often placed so closely together that the wasps may be said to form colonies. There is considerable diversity in the selection of food for their young, some species feeding them on flies, some on the nymphs of true bugs, while still others feed their young on insects of various orders and families.

Bicyrtes quadrifasciata is a very common and striking species and is recorded by Parker as occurring in Florida, Georgia, Alabama, South Carolina, Virginia, Pennsylvania, New Jersey, New York, Connecticut, Indiana, Ohio, Wisconsin, Kansas, and New Mexico. Mickel reports it from Nebraska, the Raus from Missouri, and the writer has taken it in North Carolina and Mississippi.

One day during the latter part of July, 1922, while the writer was engaged in general scouting he was fortunate enough to run upon the nesting site of this interesting species of wasp.

Previous to this time no thought had been given to a study of the life history or habits of *Bicyrtes quadrifasciata*. Literature reviewed on the subject contained only fragmentary notes; in view of these facts the writer thought it worth while to undertake a study of this species, the results of which are given in this paper.

The writer is very grateful to Professor R. W. Harned for encouragement given in the prosecution of this study and for the generous allotment of time. The writer is also indebted to Dr. C. J. Drake for the determinations of the food of the young wasps, to Mr. H. W. Allen for the determinations of the flies mentioned herein, and to Mr. J. M. Langston for his kind assistance in looking after the breeding material during the writer's absence from the office on Argentine ant work.

As mentioned above in this article the writer's attention was first attracted to these wasps during a day in the latter part of July, 1922, while walking along a public road near Adaton, Mississippi. On each side of the road for a distance of about two hundred yards was a strip of sand, which in no place was over a foot and a half in depth. The wasps were noticed flying over this strip of sand in a manner that betokened they were interested in something there. One particular wasp was observed flying over the sand as if she intended to light when she became satisfied that all was well. After hovering for a few minutes over a certain spot she finally settled on the ground and began to dig very vigorously with her front feet, throwing the sand backward through the space between her middle and hind feet, the two pairs of which formed a brace for the body. The sand came out in stream like spurts landing anywhere from six to eighteen inches from her. After digging very strenuously for a few seconds she succeeded in opening the gallery to her nest, entered and was lost to view. In a minute or less she emerged, and the writer, being anxious to discover what she was doing, drove her away and began to excavate the soil about the nest with a trowel.

The earth was sliced off bit by bit with care and the gallery of her nest traced to its terminus. The gallery or hole led from the surface of the soil to a depth of about six inches where it ended abruptly in an enlarged pocket in which were found several nymphs belonging to the families *Pentatomidæ*, *Coreidæ* and *Reduviidæ*. These nymphs, representing different stages of

development were lying flat on their backs in a perfect state of paralysis. Each nymph appeared fresh and lifelike except that it was incapable of locomotion and even when prodded with a pin would only respond by feebly moving its antennæ and legs.

After carefully examining each nymph for the egg of the wasp which was expected to be on one of them, the writer at last succeeded in finding an egg on a very large nymph. The egg was elongate, curved, and tapered from the posterior to the anterior end. In color it was a dull or opaque yellowish white. The blunt or posterior end of the egg was attached to the nymph in the space between the coxæ of the middle legs. The anterior portion or head of the egg projected from the body of the nymph towards the nymph's head. For a long time the writer was puzzled as to why the posterior portion of the egg should be attached to the nymph and not the anterior. It seemed that the reverse would be the ideal arrangement since the little waspling would upon hatching find food immediately at hand and thus be secured from any chance of starving while in a weak and helpless state. It was only after the life history was started that the writer became enlightened on this point. One day while examining the life history cages the writer was fortunate enough to find a larva attempting to eat its first meal. This was one of the most interesting observations made during the life history work and when the observation was completed the writer could not help but marvel at the adaptation. The young waspling upon hatching was of course very hungry and immediately began to search for food. After many minutes of exertion, throwing its head from side to side, it at last located the beak of the nymph and inserted its mandibles into the thin tissue separating two joints of the beak and began to imbibe the body fluid. As the fluid was pumped away from the nymph, the larva's stomach could be seen pulsating, and after several hours the fluid of the nymph began gradually to tinge the larva a greenish color. The appetite of the larva at this stage is voracious and it feeds continuously. One can almost see it grow so fast is its development. From a small microscopic worm at the time of hatching it grows rapidly and usually at the end of from three to five days is ready for pupation. In the life history work the egg and larval stages are passed in a remarkbaly short time. After having fed on the fluid of the nymph for several hours the larva becomes strong enough to pierce any part of the chitin of

the nymph and will feed on any part of the nymph's body that proves attractive to it. As far as could be determined no preference was shown for one part of the nymph's body over another. No doubt the size of the future wasp is determined by the number and size of the various nymphs placed in the nest by the mother wasp. In the life history work where only a few small nymphs were fed to a larva, in every case it developed into a small, undersized wasp while those that had plenty of food developed into well formed wasps of the average size. Without doubt the nests in the field are well provisioned by the mother wasp when she or her nest is left undisturbed. The usual number of nymphs found in a nest varied from six to eleven but nests were found during the course of study that contained only one to three nymphs. It is the writer's opinion that these nests were incomplete but it is impossible to be sure of this fact, as the mother wasp has a habit of sealing her nest on leaving for the field although that nest may still be in the process of provisioning.

One wasp was very carefully observed while digging her nest. She flew over the sand in a certain locality for several minutes, finally to light on the ground and walk over it in a very hesitant manner as if undecided where to construct her nest. After examining many cracks and crevices she at last selected a certain spot and began to dig. In this operation her head was lowered and her front feet and mandibles called into play. Her back feet, aided by the middle feet, formed a brace for the body during this work. By using her mandibles she loosened the dirt in front of her, which was kicked vigorously back out of the way by her front feet. As she worked she emitted a low humming sound which seems to be common to many of the sand digging wasps with which the writer is acquainted. In digging she would rotate her body from side to side as the operation required but she was never observed lying flat on her back during this excavating work. By continually rotating her body she kept the gallery of her nest of a more uniform diameter than she would have been able to do otherwise. After she had dug for seven minutes the writer estimated that she had proceeded about an inch. One would think that the strenuous operation of digging would tire her, but apparently not, for she kept at the work rather persistently, occasionally leaving the nest to take a few short flights after which she

would return to the nest and dig as vigorously as ever. These flights may have been due to disturbance by the writer for it was necessary that he get very close to the nest in order to make these observations. When she had excavated a few inches and was out of sight she would occasionally back up almost to the surface, where a pile of dirt had accumulated behind her and was threatening to block the gallery of the nest, and with much strength and vigor kick this out until the gallery was again free from obstructing dirt. Upon finishing this she would go below and excavate again until the dirt once more threatened to block the gallery, when she would stop and repeat the performance described above. These performances were repeated alternately until the nest was completed. After digging for an hour she came to the surface and walked around the nest for a few seconds as if looking for any faults in construction; then apparently being satisfied with her workmanship she began kicking dirt into the entrance to the gallery. While engaged in this she faced away from the nest but was close enough to the entrance so that each spurt of dirt would fall exactly into the right spot. After kicking dirt a moment from one spot she would move to another and repeat the operation, thus completely circling the nest by the time she had finished. Upon filling the entrance hole, she crawled on top of the dirt that lay there, and with her abdomen bent forward under her used the dorsal side of it in packing the dirt firmly into the gallery to form a plug. This being finished in short while she walked over the nest carefully scratching the dirt here and there that it might not leave any tell-tale trace. Satisfying herself on this point she took to the air flying in larger and larger circles until she finally disappeared. Mr. Allen and the writer timed her to see how long she would be gone from the nest, but after waiting three-quarters of an hour without success we gave her up because of the swiftly approaching dusk. We failed to learn whether she was successful in the quest of food for her future young or whether she had decided to take the evening off after so strenuous a day.

The fact that this wasp closed her nest before leaving it seems to indicate that this must be an hereditary point with them, for it seems impossible to conceive that the *Senotainia* flies which pester their nests would deposit maggots in a nest that did not contain the wasplings or their food. A number

of other wasp nests, which were closed at the entrance, similar to this one, when opened were found to be bare of nymphs or immature wasps. These observations show that the wasps close their nests before leaving them whether they are provisioned or not, though not invariably, for the writer has found nests which were open at the entrance and contained the immature forms of the wasps and their food, or were bare of either. No doubt it is the habit of the wasp to close their nests on leaving them whether empty or not and the instances just cited were most probably oversights on the part of the wasps.

The plug of dirt which closes the entrance to the nest is usually about the diameter of a pencil or slightly larger and is an inch in length or longer. Beneath this plug the gallery is free of any obstruction as is also the pocket or terminal, in which the wasp's life history is passed. One can stand directly over the nests and unless he keeps his eyes glued to the spot will lose their location so well are they concealed. The wasps, however, upon returning from the field seldom have trouble in locating their nests, although occasionally one apparently loses her nest and searches here and there for it in a state of nervous excitement. It is quite probable that most of this trouble is due to the fact that the nests are disturbed by passing teams, cars, etc., during the wasp's absence in the field.

All the nests the writer has seen were constructed in sand, possibly because sand is so much more easily excavated than other types of soil. A gallery about the diameter of a pencil or a little larger and from six to eight inches in length leads from the surface of the soil to a terminal pocket in which live the waspling with its food. The pocket is larger in diameter than the gallery that leads to it, is about two inches long and of an oval shape. The gallery may be straight or somewhat winding and connects with the surface of the soil at an angle of about forty-five degrees. The gallery is never obstructed or plugged except at the entrance to the nest.

The wasp when returning to the nest from the field with her prey usually flies in gradually diminishing circles over the nest before lighting. Even before she alights one can see the nymph which she clutches to her with the ventral side up. Upon alighting she locates the exact entrance to her nest and begins to dig, all the while holding her prey with the middle legs, while she excavates with her front feet. On no condition does she

lay her prey aside while opening her nest as the very wary little *Senotainia* fly is usually at her heels probably looking for such an opportunity. Usually after a minute of vigorous digging the wasp has removed the plug from her nest and is ready to enter.

Nine species of *Heteroptera* were found stored in the nests of these wasps. These species belonged to three different families. The species of nymphs found in the nests were as follows:

Pentatomidæ: *Acrosternum hilaris* Say., *Brochymœna quadripustulata* Fabr., *Euschistus* sp.

Coreidæ: *Archimerus calcarator* Fabr., *Leptoglossus phyllopus* Linn., *Chariestrus antennator* Fabr., *Acanthocephala femorata* Fabr.

Reduviidæ: *Zelus* sp. and *Apiomerus* sp.

The nymphs were of various sizes and stages, those of the leaf footed plant bug and the green soldier bug being most common.

In studying the life history of this wasp the contents of each nest were removed from the field to separate tin salve boxes which contained moist sand similar to that surrounding the nests. These boxes were kept in the office of the writer and were examined from day to day, each important change being recorded. The egg and larval stages were passed in a very surprisingly short time, the pupal stage occupied much more time than was expected, and for some time doubt was entertained as to whether the wasps would emerge successfully from this stage or not. For convenience the writer has tabulated the lengths of the various stages of each wasp and this data is shown in a chart following a general discussion of the insect's life history.

From the tabulated life history given below it can be seen that the minimum period in which this wasp has gone from egg to adult was 27 days, the maximum period being 44 days with a computed average of about 33 days. The egg stage occupies from 1 to 3 days with 2 days as a probable average; the larval period from 3 to 14 days with 6 days as a computed average, and the pupal stage from 15 to 40 days with 25 days as the average. No attempt was made to determine the number of generations per year as the wasps were not observed until late July, and from the first of August until late in November the writer was away from the office on business. Mr. Allen, who visited the nesting site of the wasps during the middle of August reported no signs of life present. It is not known whether the wasps had given up this site because of the frequent

disturbances or whether they left because their breeding operations for the year were completed. During these studies it was noticed that the wasps showed a fondness for sunlight and were rather inactive on cloudy or cool days. It may be assumed from this that the height of their breeding season is probably during July and August, the two hottest months of the year, and when there is plenty of sunlight available for their activities.

TABULATED STATEMENT OF THE LIFE HISTORY WORK.

Experiment No.	Days in Egg Stage	Days in Larval Stage	Days in Pupal Stage	Total Days	Remarks
1	1	5	28	34	
2	2	14	15	31	
3	2	10	15	27	Pupa never completely encased
4	1	4	24	29	
5	3	3	26	32	
6	1	3	..	..	Failed to emerge from cocoon
7	1	7	..	..	Died before encasing
8	1	5	..	..	Failed to emerge
9	1	3	40	44	
10	1	..	..	..	Larva died
11	..	..	..	..	Egg lost
12	?	?	24	..	Egg hatched, cocoon spun unobserved
13	?	?	27	..	Egg hatched, cocoon spun unobserved

While the wasps are storing their nests very small greyish flies hover above and to the rear of the wasps, or else sit on stones, blades of grass, or sticks near by, intently watching

every move of the wasps and looking for a chance to deposit maggots in their nests. The flies are ordinarily very wary and hard to capture, but so intent do they become in watching the wasps that one can capture them with little difficulty. The only opportunity they seem to have for depositing maggots in the nest is when the wasp is storing food for her young, as at other times the nest is closed by the plug at the entrance, and the wasp never lays her prey aside while engaged in opening the nest entrance. The writer has seen a fly dart into the nest immediately in the rear of the wasp, remaining below only three or four seconds to reappear again in a very hurried manner at the surface. The fly undoubtedly must have the ability of larvipositing in a very short length of time since it was observed to remain below but a few seconds at the most. Mr. Allen, who is interested in the biology and taxonomy of the genus *Senotainia* and allied groups, determined the flies captured in the vicinity of the wasps' nests as a species which he feels most certain to be *S. trilineata* V. d. W. and another possibly identical with *rubriventris* of Macquart. but more likely a distinct species. Maggots taken from the nest of these wasps by the writer and Mr. Allen and reared to maturity by the latter proved to be of the same species as the adults captured in the vicinity of the nests. According to Mr. Allen, the maggots live first as parasites of the paralyzed nymphs, later as scavengers on their decaying bodies, incidentally destroying the larva of the wasp for whom the provisions were so laboriously accumulated.

NOTES ON AMERICAN BACTRODINÆ AND SAICINÆ
(Heteroptera: Reduviidæ).

By W. L. McAtee and J. R. Malloch.

These notes have resulted almost incidentally from a more comprehensive study we have made of the American Ploiariinae, but they assemble more information than has hitherto been available on these sub-families, hence we trust will be useful.

Subfamily Bactrodinæ.

The presence of ocelli readily distinguishes this subfamily from Ploiariinæ and Saicinæ; in addition to this character the presence of but one closed cell in apical half of hemelytra (Fig. 1), elongated coxæ, and spinose trochanters, femora, and tibiæ of the fore legs, position of head, which is apparently inserted on anterior portion of the dorsum of pronotum, and the structure of the tarsal claws, distinguishes them from any allied subfamily. The structure of the claws is peculiar; both are present, one very large, with a basal tooth about half as long as the main part, and the other about as large as this basal tooth. Like the fore tarsi, the mid and hind pairs are three-segmented, but the apical segment is slightly swollen and has a short stout spine near middle on the ventral surface, which lies against one side of the large claw when this is flexed back along the venter of the segment.

Only one genus, Bactrodes, is known, a key to the species of which is given below.

Genus **Bactrodes** Stal.

Key to the Species.

1. Fore femur with three fuscous annuli on distal half; antennæ and mid and hind legs each with several fuscous annuli .... *multiannulatus* Berg.
   Fore femur with two fuscous annuli on distal half; antennæ and mid and hind legs with fewer fuscous annuli, usually one to the segment 2
2. Head and pronotum with numerous spines .... *spinulosus* Stal.
   Head and pronotum with few or no spines 3
3. A sharp anteriorly curved tubercle or spine behind each antennal insertion. .... *femoratus* Fabricius.
   No such spine present .... *biannulatus* Stal.

List of the Species.

B. multiannulatus Berg, C. Hem. Argentina Add. et Emend. 1884, pp. 112-113 [Buenos Aires Province].

B. spinulosus Stal, C. Hem. Mex., Ent. Zeit. Stettin, 23, 1862, p. 442 [Mexico]. Other locality, Guatemala (Champion).

B. femoratus Fabricius, J. C., Syst. Rhyng., 1803, p. 291 [Middle America]. Specimens examined: Paraiso, Canal Zone, Jan. 2, April 7, 1911, E. A. Schwarz (U. S. N. M.); Nord Capite de St. Paul; Jatahy, Prov. Goyaz, Brazil, 1904, H. Donckier (Paris Mus.).

B. biannulatus Stal, C. Rio Janeiro Hem. 1882, p. 80 [Rio Janeiro; this species monotype of the genus described at this reference]. Other localities, Panama, Mexico (Champion). Specimens examined: Portobello, Panama, Feb. 19, March 2, April 18, 1911, A. Busck (U. S. N. M.); Jatahy, Prov. Goyaz, Brazil, 1904, H. Donckier (Paris Mus.).

Subfamily Saicinæ.

The American forms of this subfamily examined by us agree (aside from ordinal and family characters) in lacking ocelli, in having the fore coxæ usually more or less elongate, the second segment of beak more or less bulbously expanded basally, the opposed surfaces of beak and head armed with stiff hairs, a few spine-like bristles, or spines, and the lower anterior angle of pronotum, just above coxal cavity, produced and surmounted (except in Oncerotrachelus) by an anteriorly and downwardly directed spine or bristle.

Key to the Genera.

1. Mesonotum with a long triangular process terminating in a depressed spine extending over the metanotum and basal abdominal tergite, which lack dorsal protuberances; a conspicuous spine on each side of the basal tergite projects outward, appearing to emanate from hind angle of metapleurum; basal tarsal segment shorter than third and not longer than second; venation of forewing as in Figure 2; fore femur and tibiæ without spines, armed with erect stiff hairs only; opposed surfaces of beak and bead with rows of stubby bristles..*Oncerotrachelus* Stal.

   Mesonotum not produced posteriorly, metanotum and basal abdominal tergite with dorsal tubercles or spines; no spine on side of basal tergite; basal segment of all tarsi longest; opposed surfaces of beak and head with distinct spines or spine-like bristles..2

2. Fore tibia, and femur, in part, with stiff, erect hairs, without stout spines; venation of fore wings as in Figures 5 and 7; pronotum, mesonotum, and basal abdominal tergite each with a prominent spine.................*Saica* Stal.

   Fore tibia with one, fore femur with two series of stout spines; venation of fore wing as in Figures 10 and 13..3

3. Mesonotum, metanotum, and basal abdominal tergite each with an apical tubercle; a long, sharp, outstanding spine on each side of posterior lobe of pronotum near hind angle; no curved carina on side of anterior lobe of pronotum; a short spine beneath each antennal insertion; fore coxæ short, unarmed; fore wings spotted..................................*Bagriella* new genus

   Mesonotum and basal abdominal tergite each with a long spine, metanotum with a tubercle; no spines on posterior lobe of pronotum; an arcuate carina extending posteriorly from a low rounded tubercle on front edge of side of anterior lobe of pronotum; no spines beneath antennal insertions; fore coxæ elongate, each armed with a dorsal bristle; fore wings unicolorous...... ....*Tagalis* Stal.

Genus **Oncerotrachelus** Stal.

In addition to the characters listed in the key to genera, this genus has very distinct hairs on the upper side of basal section of the radius of fore wings, the thoracic mesosternum and metasternum with a central carina, and the ventral surface of head and beak with rather dense stubby hairs, which are not arranged in tufts. The coxæ of fore legs are three or four times as long as thick, finely haired, and have two outstanding long fine hairs on anterior side; in the two tropical species there is a slight hump on the inner side, which is not visible when the coxa is pressed against the prosternum. Front femora slightly curved. Color testaceous, rather strongly marked with fuscous except in one species (*pallidus*).

Pleurosigynius Berg. (Hem. Arg. 1879, pp. 178-179) apparently is a synonym of *Oncerotrachelus;* whether its only species, *lynchii*, described from the Province of Buenos Aires, is different from the others here included we are unable to say.

Key to the Species.

1. Each posterior lateral angle of pronotum produced into a conspicuous sharp spike; median longitudinal impression of pronotum relatively broad, and rather coarsely transversely striate in bottom on anterior part of hind lobe; fore coxa as in next species; central carina of mesonotal process obsolete. ....*conformis* Uhler
   Posterior lateral angles of pronotum without sharp spikes; median longitudinal impression of pronotum linear and not appreciably striate; central carina of mesonotal process distinct..2
2. Fore coxa with a slight but distinct angulate elevation about one-third from apex below, usually with a wax-like excretion attached to apex of elevation and projecting toward apex of coxa (Fig. 3)..............*coxatus* new species
   Fore coxa without a distinct elevation as above (Fig. 4)...................3
3. Hairs on tibiæ decumbent, not longer than the tibial diameter; larger species 7–7.5 mm. in length, paler in color; posterior lateral angles of abdominal tergites not appreciably produced.........................*pallidus* Barber
   Hairs on tibiæ in part erect and very conspicuously longer than tibial diameter on at least the mid and hind legs; smaller species, 4–6 mm. in length, darker in color; posterior lateral angles of most of the abdominal tergites more or less produced and spine-like.............................*acuminatus* Say.

List of the Species.

O. conformis Uhler, P. R., Het. Grenada, Proc. Zool. Soc. Lond. 1894, p. 211 [Grenada]. Specimens examined: Balthazar, Grenada, H. H. Smith; Tabernillo, Canal Zone, June 8, 1907; Trinidad River, Panama, May 2, 3, 8, 1911; Alhajuelo, Canal Zone, May 27, 1912, A. Busck. (U. S. N. M.).

O. coxatus new species. In this uniformly colored genus no description of this species besides that given in key, seems necessary. Length, 5.5–6 mm. Holotype ♂, Trinidad River, Panama, May 3, 1911; allotype ♀, same locality, May 9, 1911; paratypes, May 2, 4, 1911, June 4, 1912; all collected by Aug. Busck; Cacao Trece Aguas, Guatemala, E. A. Schwarz and H. S. Barber, (U. S. N. M.); Igaraba Assa, Brazil, 1912 (Bueno).

O. pallidus Barber, H. G. Proc. Ent. Soc. Wash., 24, No. 4, April, 1922, p. 104 [Texas]. Only one specimen in addition to original material seen, that labelled simply Texas (U. S. N. M.).

O. acuminatus Say, Thomas. Desc. New Sp. Het. 1831, Compl. Writings 1, p. 356 [Indiana]. Made the type of the new genus Oncerotrachelus by Stal (Hem. Fabriciana, 1, 1868, p. 130). The distribution of this species as stated in the past comprised more or less of that of all of the preceding species. Specimens we have examined come from a range having the following states at its extremes: New York, Indiana, Kansas, Texas and Florida.

Genus **Saica** Stal.

Beak with one pair and head with two pairs of spines on their opposed surfaces; fore coxa with one and fore trochanters with two patches of stubby bristles; fore femur with two rows of bristles of uniform length, the degree of aggregation of which into tufts is fortuitous and has no taxonomic significance; front femora and tibiæ distinctly curved; species chiefly reddish in color with ochraceus, red-veined fore wings, most of them distinctly larger than species of the other American genera. Venation as shown in Fig. 5.

Key to the Species.

1. Fore wing with three completely closed discal cells (Fig. 5); posterior pronotal spines short, divergent, acute; mesonotal spine relatively short, acute; metanotal process expanded and broadly emarginate (but not so pronouncedly developed as in *rubripes*); spine on first tergite rather stout, almost angularly upcurved, and acute apically; spines on hind margin of male hypopygium well separated at base, upright for the basal third of their length, then diverging outwardly, the apices with a small barb on outer side (Fig. 9); second antennal segment at least one-half as long as first and 1.5 as long as fourth.......... ....*apicalis* Osborn and Drake
   Fore wing with only two completely closed discal cells......................2
2. No nearly closed discal cell basad of the two closed cells; apex of outer discal cell not attaining to level of apex of stigma (Fig. 7); spines on lower anterior angles of prothorax rounded and blunt at apices; dorsal spines on posterior pronotal lobe long and acute; genital plate of female directed strongly anteriorly (in all other species it is approximately vertical); general color testaceous, each femur with a subapical, and each tibia with a sub-basal fuscous annulus, a dark streak above over head, thorax and fore wings; abdomen marked moderately beneath and heavily above with fuscous; second antennal segment a little over one-third as long as first and noticeably shorter than fourth....................................*fuscovittata* Barber
   A nearly closed discal cell basad of the inner one; spines on lower anterior angles of prothorax long and acute; second antennal segment rarely less than half as long as first and always longer than fourth.........................3
3. The apex of outer discal cell falls distinctly short of end of stigma; abdomen slender and more narrowed basally than in the other species; dorsal spines long and acute; spines on hind margin of male hypopygium directed strongly laterad and slightly upward; general color stramineous, bases of pronotal spines, subapical bands on femora, stigma and veins at base of fore wings (in part) red; membranous parts of fore wing with more or less dusky clouding. ....*erubescens* Champion
   The apex of outer discal cell extends as far as apex of stigma; abdomen less slender and narrowed basally...4

4. Metanotal process inverted scoop-shaped, and deeply emarginate; mesonotal spine long, that of basal tergite moderate; pronotal spines long; general color pale orange red, legs without bands, wing veins red...*rubripes* Champion
   Metanotal process more or less arcuate laterally and notched but not expanded as in *rubripes*...5
5. Spines of hind margin of male hypopygium without a deep rounded emargination between their bases, directed more strongly laterad than upward (Fig. 8); dorsal spines moderately long and acute; general color pale red, coxæ, trochanters, tibiæ (except at bases), antennæ chiefly, and fore wings pale ochraceous, stigma and veins a little deeper colored.........*tibialis* Stal.
   Spines of hind margin of male hypopygium separated basally by a deep rounded emargination, directed strongly upward as well as laterad (Fig. 6); femora and distal portions of legs and antennæ dusky to fuscous; head, thorax, coxæ and trochanters red; fore wings ochraceous, the veins more or less reddish...6
6. Dorsal spines well developed.........*recurvata* subspecies *recurvata* Fabricius
   Dorsal spines shorter, blunt in the female................................
   ....*recurvata* subspecies *antillarum* new subspecies,

List of the Species.

S. apicalis Osborn, H., and Drake, Carl J. Ohio Nat., 15, 1915, p. 530 [Guatemala]. Specimens examined: Trinidad River, Panama, June 2, 1912, A. Busck; Ancon, Canal Zone, C. P. Crafts; Cayuga, Guatemala, Nov., 1915, W. Schaus. (U. S. N. M.).

S. fuscovittata Barber, H. G. Hem. Florida, Bul. Am. Mus. Nat. Hist. 33, 1914, pp. 504-505 [Florida]. Only the allotype examined.

S. rubripes Champion, G. C. Biol. Centr. Amer. Het. 2, 1898, pp. 177-178 [Panama, Colombia]. Specimens examined: Cayamas, Cuba, May 20, E. A. Schwarz; Cuba. (U. S. N. M.(.

S. erubescens Champion, G. C., Biol. Centr. Amer., Het. 2, 1898, p. 178 [Panama]. Specimens examined: Cacao Trece Aguas, Guatemala, April 9, E. A. Schwarz and H. S. Barber; Piedras Negras, Costa Rica, Schild and Burgdorf. (U. S. N. M.).

S. tibialis Stal, C., Hem. Mex., Ent. Zeit. Stettin, 23, 1862, pp. 441-442 [Mexico]. Other localities, Guatemala, Panama (Champion). Specimens examined: Chiapas, Mex., L. Hotzen; Atenas, Costa Rica, Schild and Burgdorf. (U. S. N. M.).

S. recurvata recurvata Fabricius, J. C., Syst. Rhyng., 1803, p. 286, [Middle America]. *S. rubella* Amyot and Serville, Hist. Nat. Ins. Hem., 1843, p. 372, from Guiana is regarded as a synonym. Other localities, Mexico, Guatemala, Panama, Colombia (Champion). Specimens examined: Cacao, Trece Aguas, Guatemala, March 24, 1906, E. A. Schwarz and H. S. Barber; Tumupasa, Bolivia, December, W. M. Mann; Demerara. (U. S. N. M.).

S. recurvata antillarum new subspecies. Sufficiently described in key. Length, 12 mm. Holotype ♂, St. Vincent, West Indies, H. H. Smith; allotype ♀, Balthazar, Grenada, West Indies, H. H. Smith. (U. S. N. M.).

In addition to the forms mentioned above, we have seen a damaged specimen (U. S. N. M.) of a smaller and distinct species from Texas.

Described Species Not Seen.

S. cruentata Bergroth, E., Ann. Soc. Ent. Belg., 52, 1913, pp. 234-235 [French Guiana].

S. fuscipes Stal, C. Hem. Mex., Ent. Zeit. Stettin, 23, 1862, p. 441 [Mexico]. Other locality, Guatemala (Champion).

S. ochracea Distant, W. L. Ann. Mag. Nat. Hist. Ser. 7, X, 1902, p. 175 [Ecuador].

Genus **Tagalis** Stal.

Tagalis Stal, C. Bidrag till Rio Janeiro Traktens Hemipter-Fauna, Pt. 1, 1862, p. 76. [Monobasic, *T. inornata* n. sp., genotype.]

Characters of significance common to all the species examined are: Tylus more or less tuberculate apically; eyes prominent; basal segment of beak nearly equal in length to apical two segments together; basal segment of antenna about four-fifths as long as the remaining three together; prothorax rather strongly constricted at about the middle, the anterior lobe with two rather prominent rounded dorsal swellings anteriorly, and two less prominent ones posteriorly; the mesonotum and basal abdominal tergite each with a single spine and the metanotum with a tubercle; fore femora and tibia each a little curved, the former with a series of five or six, and the latter with three, strong, curved spines on antero-dorsal surface; fore coxa moderately elongate, with an erect dorsal bristle, and two or three shorter ones on postero-ventral surface; fore trochanters with a few bristles beneath; hind legs considerably longer than middle ones, the femora of both pairs slightly clavate; fore wings membranous, with two discal cells; as in Saica, the radius is bare. Venation as shown in Fig. 10.

The length of spines on fore femora varies sexually and to some extent individually, and therefore does not seem of taxonomic import.

Key to the Species.

1. Thorax chiefly fuscous, the femora also fuscous or at least with the apices fuscous..*seminigra* Champion
   Thorax chiefly testaceous, the femora with only a subapical annulus fuscous..2
2. Median spine of male hypopygium projecting distinctly beyond claspers (as it does also in preceding species, Fig. 12); first segment of antenna without subbasal fuscous markings; larger, 5½–6½ mm..*inornata* subsp. *inornata* Stal.
   Median spine of male hypopygium projecting little if any beyond claspers (Fig. 11); first segment of antenna with traces at least of sub-basal fuscous markings; smaller 5–5½ mm.....*inornata* subsp. *cubensis* new subspecies

List of the Species.

T. seminigra Champion, G. C. Biol. Centr. Amer. Het. 2, 1898, pp. 179-180, Pl. 11, Fig. 7. [Panama]. Specimens examined: Trinidad River, Panama, May 6, 1911, A. Busck; on orchids from Venezuela, collected at quarantine, New York City, (U. S. N. M.); Mallali, British Guiana, H. S. Parish (Bueno).

T. inornata inornata Stal, C., Rio Janeiro, Hem. 1, 1862, p. 76, [Rio de Janeiro; monotype of the new genus described at this reference]. Other localities, Mexico, Guatemala, Panama (Champion). Specimens examined: Cordoba, Mex., March 30, 1900, May 16, June 13, F. Knab; Livingston, Guatemala, May 12; Cacao Trece Aguas, Guatemala, April 19, 26, 27, E. A. Schwarz and H. S. Barber; Tempisque, Costa Rica, January 20, 1921, A. Alfaro; Portobello, Panama, March 13, 1911, A. Busck; Senahu, Vera Paz, Champion, (U. S. N. M.).

T. inornata cubensis new subspecies. Description further than given in key seems unnecessary. The holotype ♂, allotype ♀, and paratype ♂ and ♀, are from Cayamas, Cuba, February 5, E. A. Schwarz; another paratype same locality and collector, January 1, (U. S. N. M.). The *Saicodes annulatus* Uhler (Check-List, 1886, p. 26, "Western States," the real locality Cuba, original specimen, now much damaged, U. S. N. M.) belongs here, and *Saica annulipes* (Uhler, P. R., Het. Grenada, Proc. Zool. Soc. 1894, pp. 210-211 [Grenada]), probably is the same. Certainly this latter insect is not a *Saica* and almost certainly it is a *Tagalis*. The description tallies with the form here described in all but two characters of any moment; if the suggested synonymy holds Uhler's name will of course replace ours.

Genus **Bagriella** new genus.

Agrees with *Tagalis* in addition to characters previously mentioned, in having the fore femora and tibiæ practically straight; and in the dorsum of anterior lobe of pronotum being more or less tuberculate at each angle. Venation as shown in Fig. 13. The genotype may be described as follows:

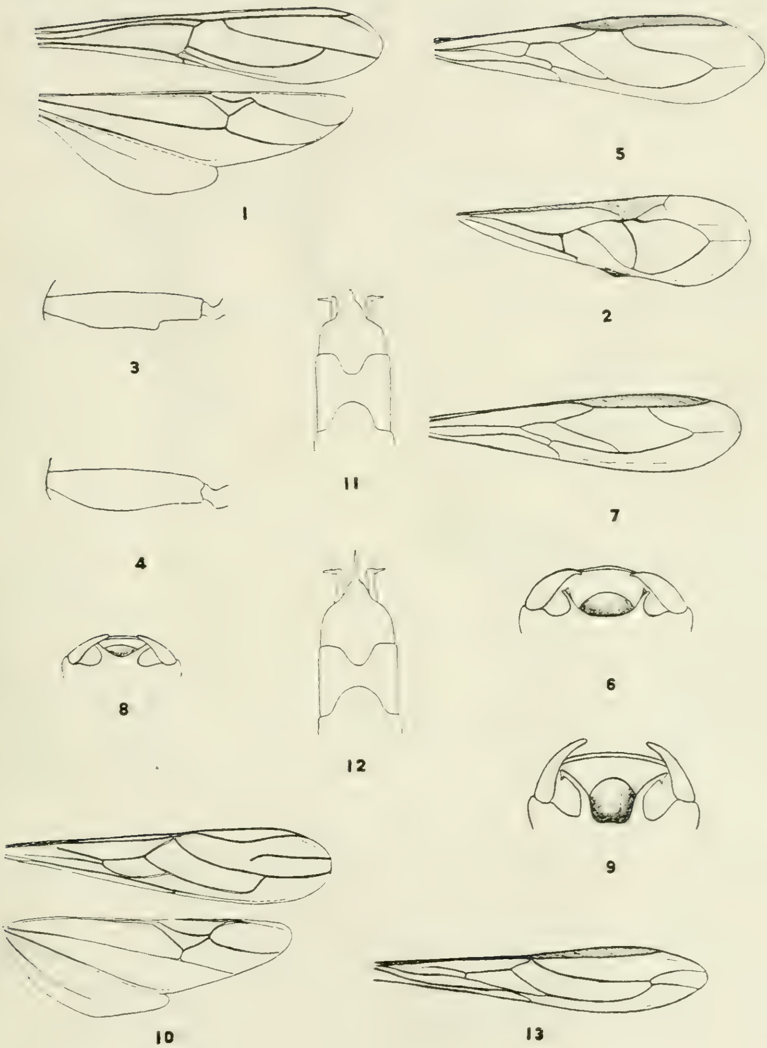
Bagriella ornata new species. General color flavo-testaceous, spines of front legs, a subapical band on each fore femur, a sub-basal one on each fore tibia, two spots on dorsum and the apex also of each fore tibia, base of second segment of beak, eyes, 3 faint bands on mid femur, and 3 on apical half of mid tibia (hind legs missing) 2 oblong spots in posterior discal cell of fore-wing, another in apical cell and fainter maculations elsewhere, fuscous.

Legs, antennæ and base of forewings with long, outstanding whitish hairs. Length, 8 mm.

Holotype ♀, Paraiso, Canal Zone, January 17, 1911, E. A. Schwarz, (U. S. N. M.).

EXPLANATION OF PLATE XVI.

Fig. 1. Bactrodes biannulatus, fore and hind wings.
Fig. 2. Oncerotrachelus acuminatus, fore wing.
Fig. 3. Oncerotrachelus coxatus, fore coxa from side.
Fig. 4. Oncerotrachelus pallidus fore coxa from side.
Fig. 5. Saica apicalis, fore wing.
Fig. 6. Saica apicalis, upper margin of male hypopygium.
Fig. 7. Saica fuscovittata, fore wing.
Fig. 8. Saica tibialis, upper margin of male hypopygium.
Fig. 9. Saica apicalis, upper margin of male hypopygium.
Fig. 10. Tagalis inornata, fore and hind wings.
Fig. 11. Tagalis inornata cubensis, apex of male abdomen from below.
Fig. 12. Tagalis seminigra, apex of male abdomen from below.
Fig. 13. Bagriella ornata, fore wing.



W. L. McAtee and J. R. Malloch.

THE ANATOMY OF THE DIGESTIVE SYSTEM OF THE CAROLINA LOCUST (D. carolina, Linn).*

By Harrison M. Tietz.

INTRODUCTION.

The typical insect dissected by most students in biology is the Carolina locust or some other common grasshopper. While many laboratory manuals describe the anatomy of these orthopterons in more or less detail, few if any, are adequately illustrated. Lack of illustration makes it difficult for the instructor to present the subject and leads to confusion in the minds of the students. It is the aim of this paper to meet this need in part by presenting in its text and figures the results of a detailed study of the alimentary tract of the Carolina Locust.

Only one other person, so far as the writer knows, has published on the digestive system of this insect. This article was written by R. E. Snodgrass in 1903 and was issued by the Washington State Agricultural College, Pullman, Washington. His work, however, is not generally accessible and at the same time fails to show structural details.

The present paper forms the third of a series of articles on the anatomy of this insect. In 1917, S. C. Vinal wrote upon the "Respiratory System of the Carolina Locust." This was published in 1919 in the Journal of the New York Entomological Society, Vol. XXVII, 1, p. 19. Later, in 1918, Dr. G. C. Crampton wrote upon the "Thoracic Sclerites of the Grasshopper Dissosteira carolina," which was published in the Annals of the Entomological Society of America, Vol. XI, p. 347.

In carrying out this work and in the preparation of the material for publication, the writer has received many valuable suggestion from Drs. H. T. Fernald and G. C. Crampton. To Dr. C. L. Bristol he owes the use of the biological laboratory at New York University during the summer of 1922. It gives him great pleasure to acknowledge here his gratitude for their kindness and encouragement.

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* Contribution from the Entomological Laboratory of the Mass. Agr. College.

METHOD OF STUDY AND PREPARATION OF MATERIAL.

In studying the gross anatomy the procedure was as follows: Specimens were captured in the field and killed in a Cyanide jar. As soon as they were dead they were dissected under water. No alcoholic specimens were used. A Spencer binocular with 10x eyepieces and 55, 40, and 25 mm., objectives were used in making observations.

Material for histological study was dissected from material not quite dead. The alimentary tract in some cases was dropped into Bouins fixitive without being opened. In others the tract was slit and the contents were brushed out under water. After fixation the usual process was followed and the slides were stained with Delafields Hæmatoxylin and Eosin. The finished slides were examined under a B. & L. compound microscope using a 10x eyepiece 32, 8, and 4 mm. objectives. A 1.8 mm. objective was also used. The best sections were those cut 7 to 10 microns thick.

GENERAL CONSIDERATIONS.

On the basis of embryology, the alimentary tract of the Carolina locust can be divided into three regions. The first of these, the fore-gut, is formed by an invagination in the anterior region of the germ band known as the stomodæum. Later this infolded portion is differentiated into mouth, pharynx, œsophagus, crop, gizzard, and cardiac valve. All these, being ectodermal in origin, are characterized by the deposition of chitin which lines their lumen. Following the fore gut is the mid-gut formed from endoderm, and producing the stomach (ventriculus) and its gastric cæca. The remainder of the alimentary tract, generally known as the hind-gut, is ectodermal in origin. This portion of the tract, formed by an invagination of the posterior part of the germ band, is known as the proctodæum, which later forms the pyloric valve, ilium, colon, rectum and anus. The lumen of these portions is also chitinized.

It would be misleading to state that the various portions of the alimentary tract always occupy the same location in the body with reference to the segments. This is true for several reasons: (1) the elasticity of the wall of the gut, (2) the loose attachment of the alimentary tract in the body, and (3) the

distentions of the various portions of the tract as they are filled with food. All these factors will determine the extent of the various portions of the gut with reference to the body segments. The writer, while making dissections of well fed and starved specimens, noted that in the former individuals that portion of the alimentary tract to which the gastric cæca were attached lay in the anterior part of the second abdominal segment, due probably to the distention of the crop and gizzard with food material. In the starved specimens, on the other hand, this area of the digestive system lay in the last thoracic segment.

THE MOUTH AND BUCCAL CAVITY.

The buccal cavity forms the most anterior region of the alimentary tract and its posterior wall is, in part, formed by the tongue or hypo-pharynx. This organ is between 3 and 4 mm. long, rather strongly chitinized, and bears upon its surface fine spines which point backward. These spines, which seem to have a gustatory function, arise from small pits. The writer intends, at some future time, to make a histological study of this organ. On the under surface of the tongue near its tip will be found the opening of the common salivary duct. This duct runs for a very short distance back towards the posterior attachment of the tongue but, before reaching this region, it divides, one branch passing to the right, and the other to the left of the insect. These branches pass into the thorax where they give off smaller branches which connect with the white grape-like clusters of salivary glands. The number and arrangement of these clusters is shown in Fig. 2. These glands are compound alveolar, each alveolus consisting of a mass of glandular cells, irregular in shape, with distinct nuclei. Some seem to be serous cells in which the secretion is scattered throughout the cytoplasm in fine granules. Others appear as mucous cells the secretion being concentrated into a clear glistening drop. In none of the sections could the writer find any indication of a reservoir for their products.

After the food in the buccal cavity has been thoroughly mixed with the saliva, it then passes into the œspohagus.

THE ŒSOPHAGUS.

This is a very short, slender tube extending first upward and backward from the buccal cavity; then, at about where it enters the thorax, bending ventrally somewhat and about the middle of the first thoracic segment joins the crop. The inner surface of the œsophagus is thrown up in longitudinal folds .16 mm. high and is covered with a chitinous coat .024 mm. thick. Under this we find a layer of columnar epithelial cells. These cells have very large prominent nuclei but very indistinct cell walls. Below the epithelium there is a layer of connective tissue which is very prominent in the central portion of the elevations where it forms the "core." Under the furrows between the ridges, however, it is very scant and seems in some places to be wanting. Next in order come the bands of longitudinal muscle. In a few cases we find a band directly under a fold but such strips are generally confined to portions lying between these elevations. The outermost layer consists of circular muscle to the depth of about .03 mm. thick. This is distinctly striated.

The so-called "molasses" glands are supposed by some writers to lie in the œsophagus. In my sections I could see no traces of glandular tissue nor distinct ducts through the chitinous lining. Under the oil immersion the chitin showed some striations but whether these were pores or merely the lamellate structure of the chitin itself the writer could not say. The chitinous intima throughout the whole alimentary tract presented the same appearance.

THE CROP.

The crop can sometimes be distinguished outwardly from the preceding region by its dilated appearance. If the insect has been well fed before dissection, the crop often stands out distinctly from the œsophagus as a sudden dilation of the alimentary tube, but in poorly fed or starved specimens one portion merges into the other so gradually that the limits of each are not clearly seen. Internally, however, the crop is transversely ridged so that it is not difficult to identify it. These ridges, about thirty in number, are about .28 mm. high and spaced .08 mm. apart. The most anterior and posterior ridges are merely a series of short disconnected folds, and the former do not bear the short chitinous teeth mentioned later on.

These teeth are .02 mm. long and are distributed, with the exception just mentioned, along the tops of the ridges in rather even rows, the broader elevations bearing three or four rows, the narrower but a single row. The teeth serve to cut the food into shreds and this seems to be one of the functions of the crop. The ridges may act in such a manner as to retard the quick passage of food into the next region (the gizzard) and so the crop may also serve as a reservoir. A third function of the crop, according to some investigators, is that of straining out foreign material from the food. This function is supposedly carried on by the teeth but Duport shows that the long teeth found in the crop of Gryllus pennsylvanicus do not prevent the passage of large particles into the stomach. In his article (Psyche Dec., 1918) he states, "Particles of chitin, quartz, and woody tissue found in the proventriculus and mesenteron were fully as large as any found in the crop. The action of the proventriculus might be compared with that of the rollers in a mill, anything caught between them is carried onward. If it is strong enough to resist the breaking power of the rollers it will come out unaltered on the other side, if not it will be crushed." Since the teeth of D. carolina are much smaller and do not project as far into the lumen as those of G. pennsylvanicus, they would be less likely to act as strainers. On the other hand, the rigidity they possess owing to their shortness, combined with the fact that they are extremely sharp, favors the theory that the teeth have a triturating function.

The histological elements in the crop are the same as in the œsophagus. The same layers are present and are in the same order. However, the ridges in the crop are transverse instead of longitudinal so we find that their relation to the bands of longitudinal muscle is different. In the œsophagus the bands run parallel to the ridges and between them. In the crop they run at right angles to the ridges. Besides this difference we also find some indication of a thicker layer of circular muscles but this is not marked.

THE GIZZARD.

The external demarcation of the gizzard is not evident for there is but a slight constriction between this portion of the gut and the crop. Posteriorly the outer wall merges into that of the cardiac valve and cannot, therefore, be differentiated from

it. Internally the gizzard can be distinguished by the presence of a series of discontinuous folds or ridge-like elevations grouped in longitudinal rows. These rows, about fifty in number, are from .004 to .008 mm. apart and project into the lumen .09 to .1 mm. Many of the elevations bear one or two teeth, .008 mm. long.

The histology of the gizzard differs somewhat from that of the œsophagus in the following details. The central portion of each protuberance contains very little connective tissue, the epithelial cells being rather tightly packed together. In the basal portion of each elevation, connective tissue is largely replaced by longitudinal muscle. Another very noticeable difference is the great development of circular muscle which is thicker here than at any other part of the tract.

THE CARDIAC VALVE.

The location of this portion of the tract is indicated externally by a slight constriction just anterior to the point of attachment of the gastric cæca. If a longitudinal section be made through the cardiac valve, it will be seen that this portion of the digestive system is very narrow and projects into the ventriculus, the latter having a larger diameter to allow for this intrusion. The small lumen of the valve is further reduced by six elevations which appear as "V" shaped islands projecting from the wall of the valve, the broad part of the V directed anteriorly, the point posteriorly, *i. e.*, near the stomach. These elevations are .5 mm. wide at their widest ends. They are 1.4 mm. long and the notches which give them the V-shaped appearance run about half their length. These protuberances are 1.3 mm. high and bear upon their surfaces fine teeth which become smaller near the apex of the V.

The cellular structure of the cardiac valve is best shown in Figs. 23 and 24. The V-shaped projections are covered with a chitinous coat .02 mm. thick under which lie the epithelial cells. Below these there is a small amount of connective tissue, and under this we find a thick band of circular muscle.

The bands of longitudinal muscle forming an outer coat of the stomach, continue anteriorly until they reach the point of attachment of the gastric cæca. Here some divide and go around on either side of the cæca, uniting on the other side where they form an incomplete outer coat of the cardiac valve. This coat

runs for a very short distance ending just below the point where the V-like projections begin. The remaining longitudinal fibres may form the outer coat of the cæca.

This portion of the alimentary tract may prevent the food from passing too rapidly from the gizzard to the stomach as well as preventing regurgitation of the food already in the stomach.

THE STOMACH (ventriculus).

There are two characters that enable one to identify the stomach without cutting into the alimentary tract. These characters are as follows: (1) the nature of the stomach wall, and (2) the presence of the gastric cæca. The wall is very thin, being not more than .02 mm. thick. This character gives it a white translucent appearance which is very noticeable. The gastric cæca which serve as a second means of identification mark, at their point of attachment, the anterior limit of the stomach. These organs, sometimes called diverticula or appendices ventricularis, are six in number and are paired, each cæcum having a single point of attachment to the wall of the stomach from which point there is directed anteriorly a finger-like lobe, and posteriorly a pouch. This finger-like lobe is nearly twice as long as the pouch and the latter is sometimes reduced making it still shorter. Both lobes and pouches are blind pockets being closed at their distal ends and open at their proximal ends into the stomach. The openings of the six pairs of cæca are not confluent but are so arranged that a line drawn through their openings would encircle the tract. The longitudinal axes of the cæca run parallel to the longitudinal axis of the alimentary tract.

In D. carolina both the anterior and posterior pouches of each cæcum are covered by a layer of smooth longitudinal muscle. The other cellular layers, however, differ both in structure and arrangement. In the anterior lobe, beneath the muscular coat just mentioned, there is a very thin layer of connective tissue though in many places this is not evident. Inside this lies the epithelium which is thrown up into twelve or thirteen longitudinal folds (Figs. 18 and 19). These folds project so far into the lumen that they almost divide each pouch into compartments. The epithelial cells are columnar with distinct nuclei situated near their bases, the cytoplasm is densely gran-

ular, and the free surfaces of each cell appears ciliated. In the posterior lobe there seems to be no definite arrangement of the cells. Many are irregular in shape, all are closely packed, and they fill the lobe with the exception of a small lumen in the center. The nuclei are very distinct, the cytoplasm not densely granulated, and none of the cells are ciliated. Although the gastric cæca are outgrowths of the stomach, this latter organ shows histological characters peculiar to itself. Instead of one layer of muscles we find two. The outermost is unstriated and longitudinal. Next to this comes a layer of circular muscle which also appears unstriated. Permeating the rest of the wall of the stomach are a few strands of connective tissue in which lie imbedded two types of cells. In the first type both the nuclei and cytoplasm stain deeply. The cells are very closely packed together with their cell walls not perceptible. They appear as dome shaped masses in longitudinal sections and as columns when viewed in cross section. Between these masses there are crypts or nests of nuclei (nidi) which form the second type of cell. Their nuclei stain well but not so deeply as in the first type. The surrounding cytoplasm remains very clear and unstained. Many of the cells appear polynucleated probably owing to the fact that their cell walls are imperceptible. They have all the appearances of being centers for the generation of new cells needed to replace those destroyed during the process of digestion.

It has been claimed that there is a chitinous intima lining the inner surface of the stomach but the writer could find no evidence of its presence. Instead that portion of the stomach wall next to the lumen was composed of disintegrating cells with here and there scattered nuclei. From the sections studied, the writer is under the impression that the nidi are centers where new cells are constantly being produced and that these cells then migrate towards the lumen where they are broken down during the process of digestion.

THE MALPIGHIAN TUBULES.

It has been mentioned that the attachment of the gastric cæca outwardly mark the anterior boundary of the stomach. For convenience the Malpighian tubules may be considered as marking the posterior limit of the stomach at the point where they are attached to the alimentary tract. It should be remem-

bered, however, that these tubules are proctodæal in origin and are not, therefore, part of the stomach. In fact the tubes enter the tract just in front of the pyloric valve.

The Malpighian tubules are threadlike in appearance, about seventy in number, and are pigmented most of their length, though near their points of attachment no color is present. In the specimens examined the color was a very dark brown and so distributed as to give the tubules the appearance of being either transversely ringed or banded and blotched. The tubes are about .05 mm. in diameter and vary in length, the longer ones measuring ten millimeters or more. They are composed of cells with prominent nuclei but with indistinct cell walls. The cells rest upon a very thin basement membrane and the latter is in close contact with trachioles that wind themselves about the tubules even to their tips. There seems to be no lumen near their points of attachment. At their point of attachment to the gut wall, the Malpighian tubules are grouped in six masses of about twelve tubes each. While the tubes do not coalesce but retain their individuality from their place of insertion to their most distal point, each group has but a single common opening.

THE PYLORIC VALVE.

The ilial muscles might force the contents of the ilium back into the stomach were it not for the presence of the pyloric valve. This valve consists of (1) a transverse fold shown in Fig. 8, and (2) somewhat spherical elevations situated just posterior to the fold. When viewed from the inner surface, this fold appears as a ditch cut transversely in the wall of the digestive tube. At the bottom of this ditch we find six cup-shaped depressions. When viewed from the outer surface, these depressions become six dome-like elevations .12 mm. high and it is to these protuberances that the Malpighian tubules are attached. These tubes as Miall states have only a secondary connection with the alimentary canal depending as it would seem upon intercellular communication and not to clearly defined ducts for the passage of waste products into the digestive tract.

The spherical elevations posterior to the fold are of the same structure as that of the ilium to be discussed later on. Anteriorly each elevation is .24 mm. in diameter but posteriorly

it is drawn out gradually, becomes narrower and at the same time slopes down towards the wall of the ilium. Finally its identity is lost for it merges into the many folds of the ilial epithelium. The longitudinal axes of these elevations run parallel with the longitudinal axis of the alimentary tract. They do not normally touch each other being spaced about .4 mm. apart. It seems reasonable to suppose, however, that when the circular muscles of the ilial wall contract, thereby reducing the diameter of the lumen, these projections may be brought together, may touch each other and thereby close up the anterior end of the ilium. Such a stoppage would prevent the contents of the ilium from re-entering the stomach.

THE ILIUM.

This is a rather short, straight, tapering tube whose posterior diameter is about one-half that of the anterior end. Externally, the limits of the ilium are only roughly indicated. One can consider that portion of the alimentary tract to which the Malpighian are attached as the anterior limit of the ilium. Posteriorly this portion of the digestive system extends to the first constriction behind these tubes.

Internally, the wall of the ilium is thrown up into many longitudinal folds that rise about .32 mm. from its surface. They are connected by similar folds which take a more or less oblique direction. These two types of elevations give to the inner ilial wall a much wrinkled appearance. Since one of the functions of the ilium is absorption, these numerous folds serve to increase the absorptive surface.

The epithelium forming the folds consists of a single layer of cuboidal cells whose free surface is covered with chitin to a depth of .008 mm. The central portion of each fold is loosely filled with connective tissue upon which these cuboidal cells rest. Next comes a thin coat of circular muscle outside of which and forming the outermost portion of the ilium, there are about six bands of longitudinal muscle.

THE COLON.

It is often difficult to recognize the colon without cutting through its wall and examining the internal structure. When the six longitudinal bands of muscles, to be mentioned later on,

appear through the wall and when the constrictions between the ilium and colon, and colon and rectum are pronounced, external identification is made much easier.

Internally, however, this portion of the alimentary tract presents unmistakable characters that would prevent its confusion with any other region of the digestive system. The outstanding features are the six longitudinal folds, .24 mm. high, that project into the lumen of the colon.

They are about .2 mm. broad and are placed about .012 mm. apart. The tops of these elevations are not flat but, on the contrary, present under the microscope a rather undulating appearance. These elevations are continuations of the ilial folds.

The histology of the colon is quite similar to that of the ilium with the exception that the chitinous intima in the colon is thicker being .012 mm. in depth. There is also a noticeable increase in the amount of circular muscle. The longitudinal muscles of the colon are merely continuations of the ilial muscles.

THE RECTUM.

The rectum begins just behind the last constriction of the alimentary tract, this constriction marking it off from the colon. From this point it dilates then gradually tapers to the anal opening. In addition to this character, the six bands of longitudinal muscles that appear as dark streaks on the outer rectal wall, also aid in fixing the limit of the rectum although the muscular bands may sometimes be seen on the colon wall as well.

Upon dissection it will be noticed that the six folds in the colon have been continued into the rectum, where they have undergone some modifications. In the rectum the folds have been reduced in height to .12 mm., but their width has been increased to .58 mm. at their widest part though they become narrower as the rectum tapers. With an increase in the width of the folds, there is a proportional decrease in their distance apart, each elevation rising within .008 mm. of its neighbor causing the intervening furrows to be very narrow. Lastly, the surface of the rectal folds are fairly smooth and flat.

The musculature of the rectum consists of a thin layer of circular muscle outside of which lie six rows of longitudinal muscles. These longitudinal muscles are placed just opposite the

furrows between the rectal folds and are, therefore, external indications of the location of these elevations.

The epithelium of the rectum consists of columnar cells closely packed together whose nuclei and cell walls are well marked. The chitin lining the lumen appears, in all my sections, to be very thin.

At the posterior end of the rectum, all the characters that have just been mentioned are lost or become very indistinct. Finally the rectum opens to the exterior through the anus. The anus marks the posterior limit of the intestine and is situated above the genital opening.

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EXPLANATION OF PLATES XVII—XXI.

Fig. 1. Sagittal section of the alimentary tract in situ.
Fig. 2. General external view of the alimentary tract from dorsal surface.
Fig. 3. Longitudinal profile of the alimentary tract (vertical and horizontal scales different. Letters refer to the location of the sections figured.)
Fig. 4. Diagrammatic reconstruction of the oesophagus.
Fig. 5. Diagrammatic reconstruction of the crop.
Fig. 6. Diagrammatic reconstruction of the gizzard.
Fig. 7. Diagrammatic reconstruction of the cardiac valve.
Fig. 8. Diagrammatic reconstruction of the pyloric valve.
Fig. 9. Diagrammatic reconstruction of the colon.
Fig. 10. Diagrammatic reconstruction of the rectum.
Fig. 11. Section through an alveolus of a salivary gland.
Fig. 12. Cross section of the oesophagus.
Fig. 13. Long. section of the oesophagus.
Fig. 14. Cross section of the crop.
Fig. 15. Long. section of the crop.
Fig. 16. Cross section of the gizzard.
Fig. 17. Long. section of the gizzard.
Figs. 18 and 19. Cross sections of the cardiac valve.
Fig. 20. Cross section of the cardiac valve at the point where the posterior lobes of the gastric cæcæ open into the stomach.
Fig. 21. Cross section of a Malpighian tubule with trachea.
Fig. 22. Long. section of a Malpighian tubule.
Fig. 23A. Long. section of the cardiac valve.
Fig. 23B. Epithelial cells from the anterior lobe of the gastric cæcæ showing cilia?)
Fig. 24. Long. section of the cardiac valve between gastric cæcæ.
Fig. 25. Cross section of the stomach.
Fig. 26. Oblique cross section of the stomach.
Fig. 27. Long. section of the stomach.
Fig. 28. Oblique long section of the stomach.
Fig. 29. Cross section pyloric valve.
Fig. 30. Long. section pyloric valve.
Fig. 31. Cross section of the ilium.
Fig. 32. Long. section of the ilium.
Fig. 33. Cross section of colon.
Fig. 34. Long. section of colon.
Fig. 35. Cross section of rectum.
Fig. 36. Long. section of rectum.

Key to Abbreviations.

A.—Hypopharynx.
B.—Salivary Duct.
C.—Oesophagus.
D.—Crop.
E.—Salivary Gland.
F.—Gizzard.
G.—Anterior lobe of Gastric Cæca.
H—Posterior lobe of Gastric Cæca.
I.—Malpighian Tubule.
J.—Trachea.
K.—Stomach.
L.—Ilium.
M.—Colon.
N.—Rectum.
O.—Anus.

ci.—Cilia.
c. d.—Cup-shaped Depressions.
chi.—Chitin.
c. m.—Circular Muscle.
c. t.—Connective Tissue.
c. v.—Cardiac Valve.
d.—Duct.
d. c.—Disintegrating Cells.
epi.—Epithelium.
l. m.—Longitudinal Muscle.
m.—Membrane.
m. c.—Mucous Cells.
n.—Nidi.
p. v.—Pyloric Valve.
r. g.—Rectal Gland.
s. c.—Serous Cells.
t.—Teeth.
tr.—Trachea.
v.—V-shaped Islands.

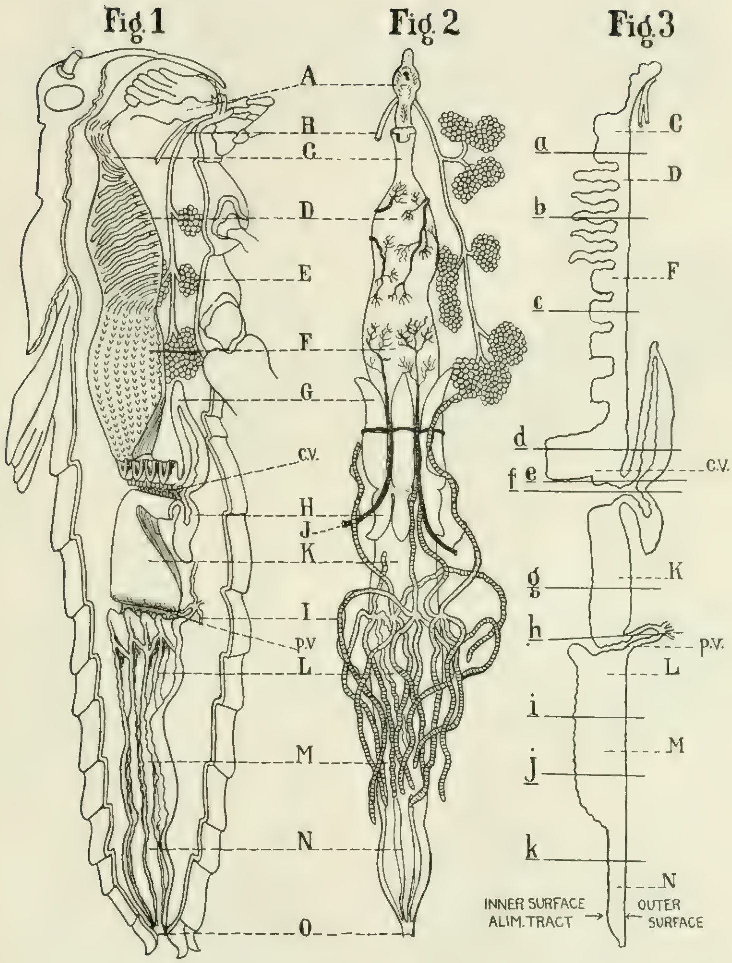

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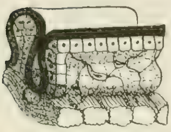
Fig. 4



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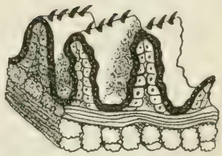

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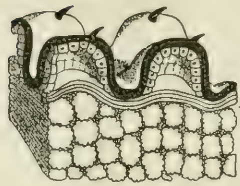

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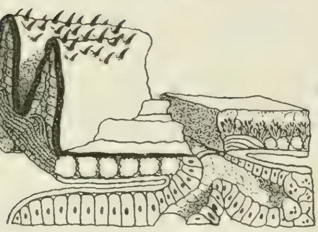

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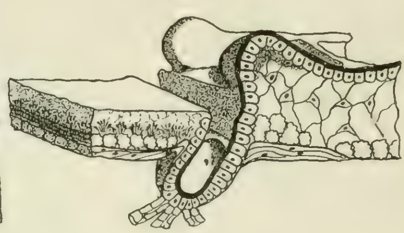

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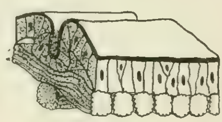

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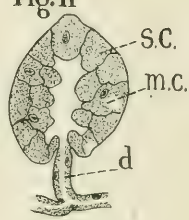

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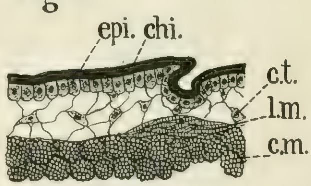
Fig. 13



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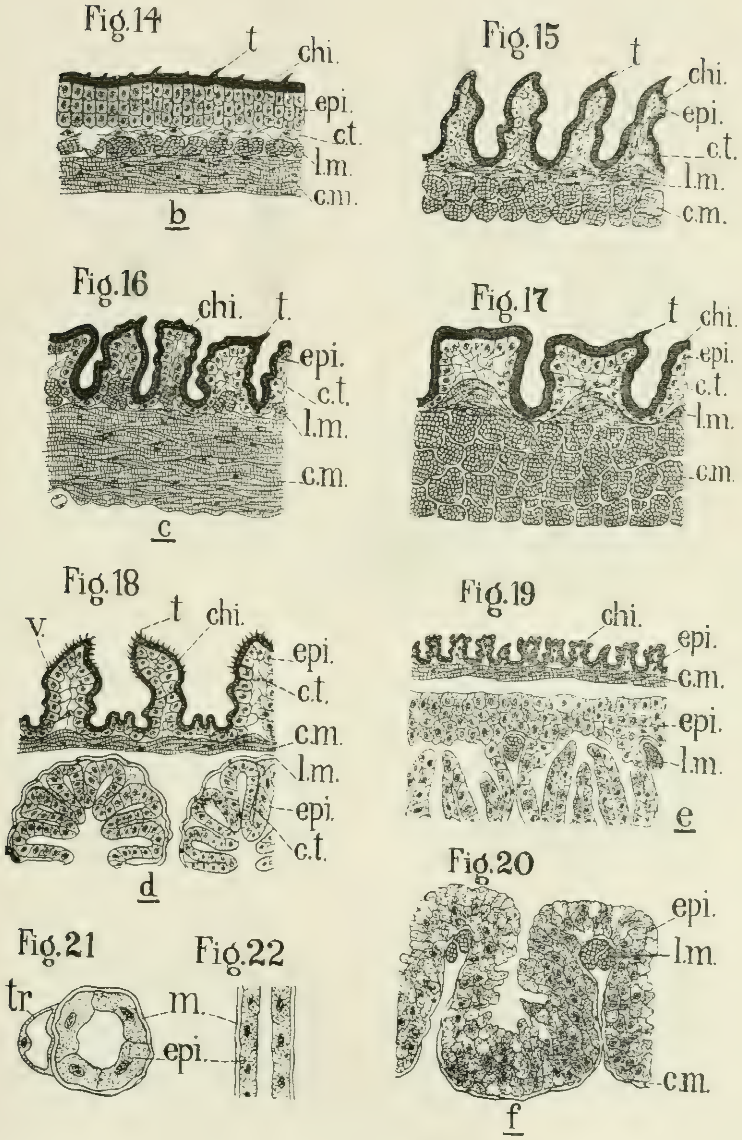

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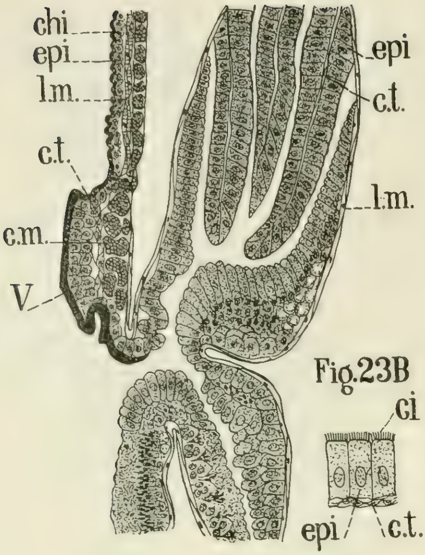
Fig. 23A

Fig. 23B



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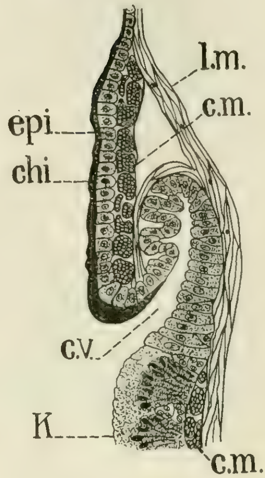

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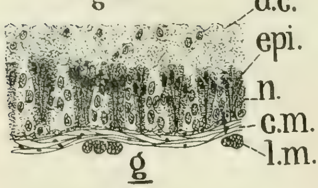

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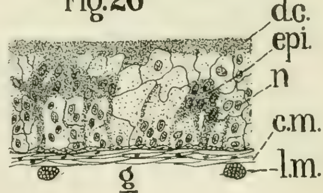

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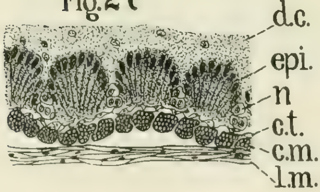

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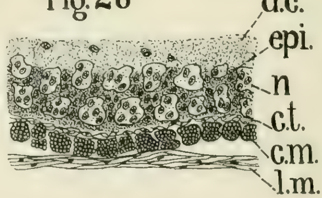

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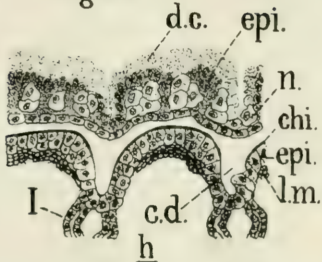
Fig. 29



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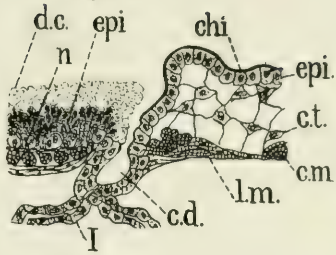

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Fig. 32

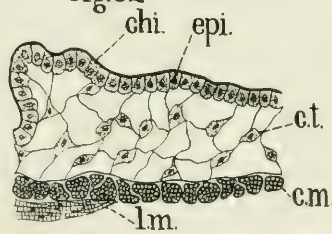
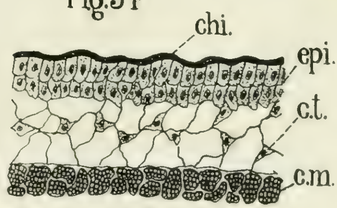


Fig. 33

Fig. 34



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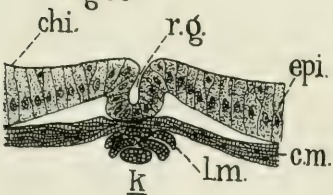

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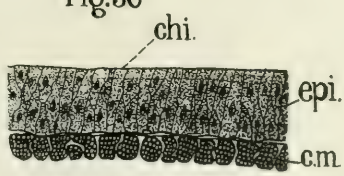

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NOTES ON COLLECTING INSECTS IN THE MARQUESAS ISLANDS.

F. L. Washburn.

On September 8, 1922, I sailed from San Francisco equipped for a collecting trip in the Marquesas and Society Islands, having been granted a six months sabbatical leave by the University of Minnesota for that purpose. Before my return and because of the uncertainty of travel to and from the Marquesas, this leave was extended to cover eight months.

Returning recently, it has occurred to me that members of the American Society and other Entomologists would be interested in the results.

We did not expect to find in the Marquesas any brilliant forms, and in this were not disappointed, but we were agreeably surprised in meeting with far more insects, both species and individuals, than we expected.

It is too early to speak definitely of the species taken, but the following data may be acceptable to collectors and particularly to any entomologist planning a trip to this far-away country.

Our equipment consisted, in addition to many and various nets and extra scrim, and cyanide jars—of 6-inch glass vials filled with a 4% solution of formaldehyde, many round tin salve boxes, as well as large square and oblong tin boxes, adhesive tape and (to protect the latter when used to seal the boxes, from the effect of moisture) a supply of waxed paper. We also took cellu-cotton, and most important, an iron kerosene lamp with two broadwicks and a small iron drying oven. Equally important were two iron-lined wooden boxes about 14 x 14 x 16 inches with rabbetted covers, which drew down very tightly by means of trunk cover clasps. A supply of napthalene crystals was included in our outfit, and more useful still, almost indispensable, crystals of tetra-di-chloride of benzine. This latter we found excellent in ridding our trunks of cockroaches before returning to civilization, though its chief use is given below. We also took a lantern trap (which proved nearly useless) extra cyanide and ether and chloroform. Trowels, knives, forceps, etc., were in evidence, and we added a small bore shotgun and ammunition, cotton, arsenic and alum, for collecting birds and making skins; a rifle to secure fresh meat (wild goats, pigs and cattle) also formed a part of our outfit. We provided ourselves with two good cameras, many "tropic" films in machine-sealed metal containers, two field developing outfits and plenty of chemicals for developing. A thermometer to use in testing temperature of water in developing is highly important. An extra tripod or two should have been packed with our luggage. An army cot, mattress and mosquito canopy, double blanket and pillow we found necessary, and a good field glass

proved very useful. Ammonia for alleviating poison effects of centipedes and a medicine kit for emergencies were wisely added. These things filled two large packing cases, and when I saw natives struggling in the surf to get our luggage on the beach at Tuahuku on Hivaoa without wetting it, I resolved that on a second trip I would put everything possible into strong sacks, and avoid large boxes.

Immediately after insects were killed, i. e., after I had returned to camp, some were placed in formaldehyde in vials and localities marked on the corks. Of course most of our specimens were dried. Those intended for drying were laid on cellu-cotton in the above mentioned tin boxes and placed in oven over lamp. Drying took from four to seven or eight hours. When in our estimation they were dry, a layer of cellu-cotton was placed over them, a few crystals of paradichloride of benzine scattered on this, the cover replaced and a band of adhesive tape run around the box. The data were scratched on box. It followed only to wrap each box in waxed paper, fasten same on with rubber band and pack boxes in our small iron-lined chests where they were safe from attack by insects, rats, mice or mould. Some of these boxes have been opened since reaching home and specimens have been found to be in excellent condition.

Most of the insect specimens were collected from 50 to 100 feet above the sea, but many were taken between a 1,000 and 2,000 feet elevation and some at 2,800 feet. In almost every order we have sufficient specimens to allow of exchange with other institutions.

Hymenoptera led in point of numbers and in this order a large imported Vespid was extremely abundant and at times troublesome. Everywhere imported honey bees (and for the most part a good strain of Italians) were kept by natives, in such primitive hives and in so unskilled a manner that we knew, even before we were told, that there were many escaped swarms and much wild honey. We took four species of *Formicidæ*, one species, perhaps two of *Ichneumonidæ*, and reared a few parasites from scale insects.

Of *Lepidoptera* we obtained three species of diurnals, including one apparently identical with our *Anosia plexippus* and this was found in varying abundance on the four islands visited, namely, Hivaoa, Tahuata, Uapu and Nukahiva. Two handsome Sphingids, some Noctuids, and other small nocturnal forms were taken. I did not observe the Monarch on either Tahiti or Morea, but it doubtless occurs and has been so recorded.

Diptera.—The Marquesas yielded a black Syrphid with yellow bands and a most interesting robust form with metallic reflections, which I found very abundant. Two or three species of mosquitoes were taken and we were especially interested in discovering that the famous "No-No" or "sandfly" occurring in great numbers on Nukahiva were Simuliids, genus and species to be determined later.

Many fruit flies were taken on rotting mangoes and guavas.

Houseflies were common everywhere, but not very abundant or troublesome.

A few specimens of Aptera were secured on Nukahiva. The presence of many dogs on all these islands insures the finding of fleas anywhere, though strangely enough we examined a dozen or more house rats, very common everywhere, immediately after death, and found none.

In *Homoptera* we took many Coccids, several species of Aleurodids, a few species of plant lice. In *Heteroptera*, a few bugs.

It is interesting to note that in three months of work in the Marquesas I found no insect which passes its adult stage in or on water. On Tahiti, in the Society group, I took one Hydrobatid.

In *Odonata*, which were quite numerous as to individuals, perhaps six species were taken.

Orthoptera yielded Gryllids, two or three species of "walking sticks," several locustids, one very large green Acridid, taken only in one valley on Nukahiva, and of course we found Blattids in abundance.

In *Coleoptera* several species of Cerambycids were captured, as were one or two forms of Coccinellids, a handsome green and bronze Buprestid occurring to the best of my knowledge only in Uapu and Fatuhiva; several species of Ryncophora; some Staphylinids were taken in rotting fruit.

Neuroptera: A lace-winged fly, closely resembling Chrysopa, was present, on all the islands visited, in thousands. On Tahiti (Society group) an interesting Ant Lion, looking like our Myrmelon, was secured.

Euplexoptera: Represented in our collection by one species.

Isoptera: A few white ants secured. These, by the way, are becoming very abundant and troublesome in Tahiti.

The trip from Tahiti to the Marquesas, 790 miles away, can only be taken in small trading schooners, occupies from 6 to 9 days, or frequently 15 or 20, or more depending upon whether or not the boat goes through the Paumotus, and the journey is a hardship.

But little in the way of equipment can be purchased in these islands; it has to be carried in and one is wise to take everything in duplicate as far as possible. An emergency kit of medicine is an important part of the outfit and we would strongly advise one taking about three times as much iodine as he deems necessary, for wounds heal slowly and the chance for infection is great. Clinical thermometers should not be forgotten. It is of the utmost importance to take a saddle and bridle from America. In the Marquesas one is dependent upon their small horses (Peruvian stock) for transportation and the above commodities are hard to obtain, costing more than the horse.

A pup tent may be found very useful. One should also take two or three pairs of strong army shoes or cruising boots. The volcanic rock is hard on shoe leather. Light shoes or slippers are also advisable for use after day's work. Thin clothes and cork helmets can be bought cheaply at Papeete, Tahiti. Helmets are necessary; no white man can work in the sun in a straw hat; at least we could not. A good flash light (or better, two flash lights) will be found very serviceable and necessary.

Since money is not always desired by the natives, articles for trading (to secure labor and other service) are useful. The following will be found acceptable: Pipes, tobacco, caps, shirts, playing cards, watches, (the latter only given for great favors) mouth organs, whistles, flash lights, fish hooks, belts, necklaces, dolls and colored calico. Letters of introduction from prominent officials in this country are most acceptable to the French government. We found them very useful.

Finally, one should avoid using large boxes for his equipment. Strong sacks are preferable, as landings in the Marquesas are for the most part very difficult.

TECHNIQUE IN STUDYING BY DISSECTION THE INTERNAL ANATOMY OF SMALL INSECTS.

Ralph H. Smith,
San Francisco, California.

While engaged a few years ago in studying the morphology of the digestive apparatus of some small Hemiptera, including Coccidæ, Aphididæ, Tingidæ, Cicadellidæ, etc., the writer hit upon a method of dissection, some features of which apparently have not heretofore come to the attention of students of morphology. Brief description of the technique is given herewith.

Delicate dissecting knives and needles are made by grinding down needles ranging from the fine cambric needle to darning needles. Surgeons' needles are very suitable. These are inserted in sections of slender stems or sprouts of woody plants, which serve as handles. Finishing of the edges and points, as also the delicate points on forceps, is done on a fine carborundum under a binocular microscope. A Syracuse Dish or Stender Dish is partially filled with paraffine of a fairly high melting point. The insect, with the wings and legs removed from one side, is held with the fine-pointed forceps. Using a blunt, heated needle, a small place is melted in the paraffine and the lower one-half or two-thirds of the insect's body—the side having the appendages intact—is submerged in the melted paraffine. By using a needle, frequently heated, the paraffine is brought in close contact with the integument. The dissecting dish is then filled with normal salt solution.

The dissection is performed as follows: Insert point of the dissecting knife through the integument and cut outward along edge of the firm paraffine. Then with fine forceps and dissecting needle, carefully lift away the upper half of the exoskeleton. The internal organs are thus exposed in their natural positions. The tissues of minute insects are so delicate and so nearly transparent that a staining reagent must be used to differentiate the various organs. For this purpose, a weak aqueous

solution of iodine is found much superior to the stains ordinarily employed in such dissection work. A medicine dropper with the end drawn to a suitably fine point over a gas or alcohol flame, is used to best advantage in applying the iodine solution.

To bring out the salivary glands, for example, a delicate stream of the iodine is forced against the tissues of the head. The different tissues respond immediately, though in slightly different degrees. All tissues are contracted, but as the iodine diffuses in the water, they relax to approximately their natural size, shape and color. Care must be given to cleaning the dissection instruments after using, as the iodine and salt corrode them quickly.

When the higher power objectives and oculars of the binocular microscope are used, as usually is necessary, very strong light is required. In this case the dissecting stand is placed in direct sunlight, or the rays from a high power electric lamp are condensed through a bull's eye lens, or a microscope lamp may be used to illuminate the object; each method having given satisfactory results. The use of paraffine for holding larger insects and larvæ in position while dissecting, is often much more satisfactory and expeditious than the method of pinning as employed by many students of insect morphology. Likewise, the iodine solution works equally well with the larger insects.

ANNALS

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Volume XVI DECEMBER, 1923 Number 4

FACTORS AFFECTING THE PROPORTION OF ALATE AND APTEROUS FORMS OF APHIDS.

F. M. WADLEY.

INTRODUCTION.

This paper embodies the results of work done by the writer while pursuing graduate work at the Kansas State Agricultural College. Experiments on factors affecting wing-production in aphids were carried on from September, 1919, to March, 1920. A second series of experiments were conducted in December, 1921, and January, 1922. Considerable work was done while away from college in rearing, preparing and drawing specimens. Credit is due Dr. M. C. Tanquary, under whom the writer began the work, for suggesting the investigations and furnishing starting points; and to Dr. Tanquary, Dr. R. C. Smith and Prof. G. A. Dean for many helpful suggestions. The object of the experiment was to study the factors causing appearance of the different forms of aphids; to test conclusions reached by other workers; to look for any previously unsuspected factors; and endeavor, if possible, to formulate a theory which would account for all results.

Four explanations have recently been put forward to account for the appearance of winged and wingless forms of aphids. Ewing (6) found that temperature was an important factor, and that fewer winged aphids were produced at a moderate temperature than at higher or lower temperatures. Gregory (7) found that aphids which had been starved during development produced winged progeny, and that nutrition is a most important factor. Shull (18) pointed out that winged aphids pro-

duced a large number of apterous progeny, and wingless ones produced many alate progeny, and concluded that parentage was the dominant factor in wing-production. Work begun by Clarke (2), continued by Neills (11) and Woodworth (20), and elaborated by Shinji (16), showed that chemicals acting on the food-plant affected the parentage of winged aphids produced.

Six species have been reared in a preliminary way to test their suitability for this work. At the beginning, in September, 1919, four were reared; including a species common on corn and sorghum; one which had been previously reared on strawberry; one found on squash, which was neither of the aphid species common to that plant; and one abundant on wheat in the college greenhouses. None of these were then determined. The fourth species, since determined as *Rhopalosiphum prunifoliæ* Fitch, was soon recognized as best fitted for the work, and was used in all the experiments, the other species being discarded. In 1921 the pea aphis, *Illinoia* (*Macrosiphum*) *pisi* Kalt, then abundant on alfalfa, was reared for a time and found to be fairly well suited to experimental work of the sort the writer has attempted, except that it was very susceptible to disease. In January, 1922, a light green aphid species common to wheat was reared for a short time. It proved much less suitable than Rhopalosiphum. In all the experiments the aphids were reared on wheat, and in most cases in cages made by placing cloth-topped lantern globes or cotton-stoppered lamp chimneys over wheat plants growing in flower pots. Exceptions will be explained later. Transferring was usually done with a small brush. All were reared in constant-temperature chambers in the insectary except for a few kept under outdoor temperatures.

NOTES ON RHOPALOSIPHUM PRUNIFOLIÆ FITCH.

GENERAL NOTES.

The species of Rhopalosiphum used in 1919 and 1920 were identified by Dr. E. M. Patch, and those used in 1921 and 1922 by Dr. A. C. Baker. It has been commonly known as *Aphis avenæ* Fab., and in older literature as *Siphocoryne avenæ* Fab., but Patch and Baker state that the species was first correctly described as *prunifoliæ* by Fitch and that this name must hold. While it is sometimes classified as *Aphis prunifoliæ* Fitch, in Dr. Baker's new classification the species falls in the genus

Rhopalosiphum. The life history has been outlined by Pergande (13) and by Baker and Turner (1.) The species is widely distributed over the United States and the world. It is most common on wheat and oats, and on apple as a winter host, but occurs on a number of grains, grasses and other plants.

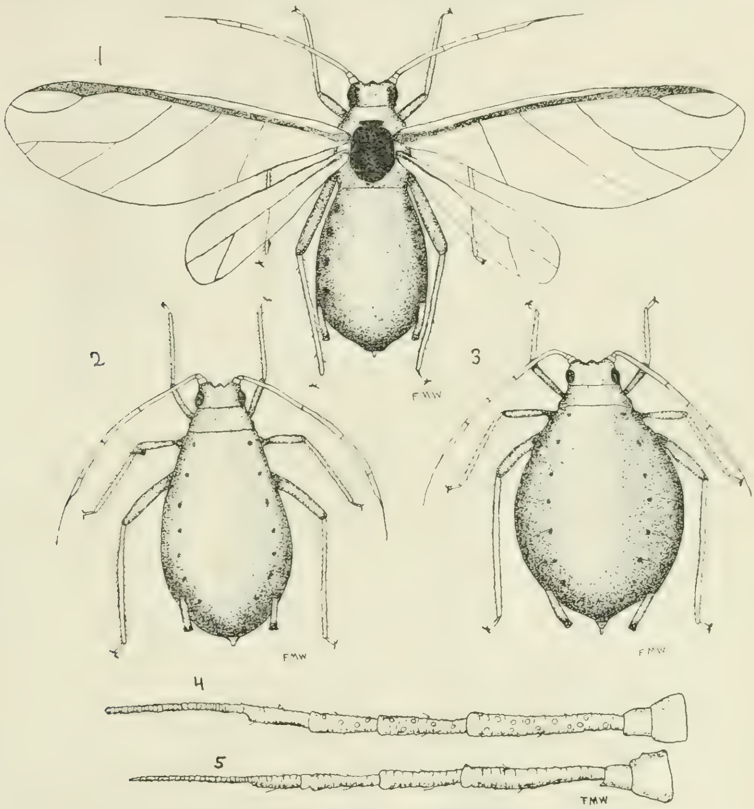

FIGURE I. *Rhopalosiphum prunifoliae* Fitch.

1—Winged adult, x 20. 2—Wingless adult, newly-matured, x 20. 3—Wingless adult, several days after maturity, x 20. 4—Antenna winged adult, x 50. 5—Antenna wingless adult, x 50.

The winged adult (Fig. I) is 1.6 to 1.8 mm. long, and 0.7 to 0.8 mm. in greatest width of body. The wingless adult is 1.8 to 1.9 mm. long and 0.8 to 0.9 mm. in greatest width. The newly born nymph is 0.7 to 0.9 mm. long and 0.3 to 0.4 mm. wide. The nymphs are light green at birth, their color deepening somewhat during growth. Reddish areas are found

about the base of the cornicles in both nymphs and wingless adults. These are characteristic of the species in its occurrence on grain. The winged adult is dark green, with no trace of red, and with black head, appendages and thoracic lobes. These descriptive notes apply to the summer forms, which are the most common of the forms in Kansas.

BIOLOGY.

Development from birth to maturity requires from 5 to 6 days at 80° F., and 6 to 7 days at 70° F. At higher temperatures the life cycle is not shortened, but is greatly lengthened at lower temperatures. Development ceases when temperatures fall below about 40° F. The four nymphal instars require respectively about 36 hours, 36 to 48 hours, 36 to 48 hours, and 24 to 36 hours, at 75° F. Females begin reproducing from a few hours to two days after the last molt. At ordinary temperatures the reproductive period lasts from 5 to 12 days and an adult may live several days later, so that females often live nearly a month. All periods are prolonged at low temperatures. Baker and Turner state that winged females require longer for development than wingless ones. This has been observed by the writer, especially in the later instars. With alate females a longer time usually elapses between the last molt and first young.

Early in the reproductive period the apterous females produce from 8 to 11 young a day and the total progeny may exceed 75, while with alate females from 6 to 9 young a day are often produced for a few days, and the total progeny may approach 50. In one typical set of experiments carried out after methods were well established and mortality low, the progeny of alate females averaged 19, and the progeny of apterous females 47.

A generation requires 5 to 7 days at 80° F., 7 or 8 days at 70° F., 10 days at 60°, and may require a month at an average temperature of 45° F. While the aphids can endure for a short time temperatures approaching 100° F., they die if such temperatures are maintained long, and do not thrive when the average temperature is above 80°.

While the males, oviparous females, and winter eggs occur in Kansas the species is evidently not dependent on them for hibernation. The summer forms have been found on grain

in this and neighboring states, during all the winter months. During two winters a few aphids have been kept alive in pot cages at outdoor temperatures until late in January. In one case a nymph survived a temperature of −16° F. It seems evident that the summer forms on grain commonly hibernate in Kansas. The males and oviparous females have not appeared in the winter colonies, under the influence of autumn cold, or of long rearing in a parthenogenetic line. In some cases apple cuttings were supplied, but the aphids refused to go to these, and when placed on them returned to wheat. The writer reared the species in one case 19 generations, in another 35, while Ewing (6) reared the same species 87 generations in a parthenogenetic line. It seems certain that under favorable conditions the species may continue indefinitely without appearance of the sexes.

DIVERGENCE IN DEVELOPMENT.

The divergence of apterous and alate forms during development is important from the standpoint of this paper. Differences develop both in form and color. This divergence is illustrated in Fig. II.

The nymphs destined to be alate are broader across the abdomen than those which will become apterous, and about the same width, if not a little narrower in other parts of the body. This gives them early in development a slightly pear-shaped appearance which is distinctive. The development of wing-pads in the later instars distinguishes them from apterous nymphs still more plainly. The two types of nymphs average about the same size throughout development, the alate nymphs being wider at the place of greatest width, owing to the shape of the abdomen, and usually a little longer. As maturity is approached the apterous forms attain the greater size.

The new born aphis is light green with reddish areas around the cornicles, and deepens in color with development. In the nymphs which will be apterous the green deepens slowly, and the red is blended with it. In those which will be alate the green deepens faster, especially in the region of the future thoracic lobes, and just posterior to it, and the reddish color contrasts with the green. After maturity the alate form does not change perceptibly in appearance, but in the apterous

aphid the color keeps on deepening, until in old wingless females the green has often deepened almost to black, and the red is obscured. The newly matured apterous aphid has the general appearance of a large nymph, but becomes broader and darker with age.

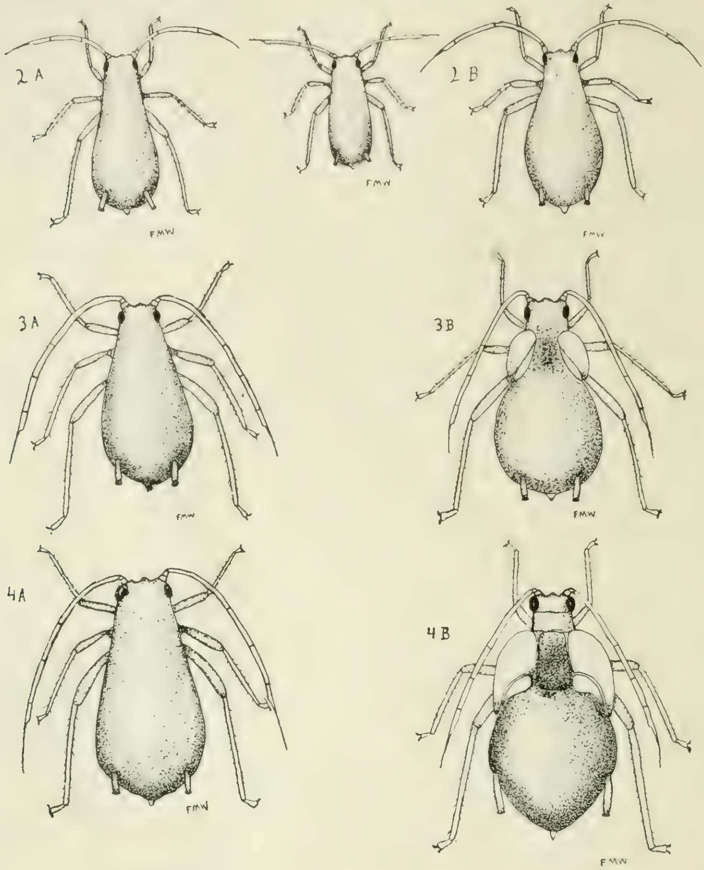

FIGURE II. *Rhopalosiphum prunifoliae* Fitch.

1—Nymph in first instar, x 20. 2A—Nymph in second instar, destined to become apterous, x 20. 2B—Nymph in second instar, destined to become alate, x 20. 3A—Nymph in third instar, destined to become apterous, x 20. 3B—Nymph in third instar, destined to become alate, x 20. 4A—Nymph in fourth instar, destined to become apterous, x 20. 4B—Nymph in fourth instar, destined to become alate, x 20.

In the first instar no difference appears. In many cases circumstances after birth may cause development in either direction. In others, previous circumstances have determined

the fate of the wings. In the second instar, while divergence is frequently noted, both in form and color, it can be detected only by an experienced worker. Experiments indicate that circumstances during this instar may still cause development or suppression of wings, in case their fate has not already been determined. In the third instar the wing pads appear, and in the fourth they become conspicuous. The other differences become accentuated and the alate nymphs are sharply differentiated from those destined to be wingless. All experiments seem to indicate that the fate of the wing pads is determined not later than the latter part of the second instar, and that after the second molt circumstances cause no change in the form of the aphid.

EFFECT OF PARENTAGE.

Shull (18), working with *Macrosiphum solanifoliæ* Ashm., showed the influence of parentage on aphid forms, and emphasized it in his conclusions. He found that the progeny of alate individuals were mostly apterous, and the progeny of apterous aphids included many alate. He also pointed out that winged males were the progeny of apterous mothers, and that wingless oviparous females were the offspring of alate females. From rearing records he traced a transition from preponderance of apterous to predominance of alate forms in the parthenogenetic phase of the cycle, and from predominance of males to predominance of females in the sexual phase. From these data he related the four forms to Riddle's theory of sex (15). He regarded the alate viviparous females and the males as forms of high metabolism and low energy content, and the apterous viviparous females and the oviparous females as forms of low metabolism and high energy content.

The influence of parentage was tested by the writer by rearing the progeny of numerous females, both alate and apterous, and recording the number of winged and wingless among the progeny. This work was all done in the temperature chambers, and as there were two of these, two sets were run at once. Thus the tests on the effect of parentage and the temperature formed a compound experiment. The Temperatures used are explained under "Effect of Temperature." The plan was to run 4 cages with each generation, as follows:

One with an apterous parent, the descendant of a line of apterous ancestors; one with an alate parent, the descendant of an alate line; one with an apterous parent, the progeny of an alate mother; one with an alate parent, the progeny of an apterous mother. It was found impossible, however, to maintain an alate line, though two consecutive alate generations were secured in several cases. The other three series were carried through as planned, and little difficulty was found in securing parents for the cages. One parent was used for each cage, and her entire progeny reared. At first it was necessary to move the parent to another cage as her oldest progeny neared maturity, since they would often begin reproducing before she ceased, and the small young would be confused. After a little practice, however, it was easily possible to detect whether a young aphid would be winged or wingless at least two days before maturity, by the presence or absence of wing-pads. The young were then removed and recorded before maturity. As will be set forth later, nutrition was found to be of extreme importance in wing-development. It was believed that the best way to keep nutrition uniform while testing other factors was to keep it near the optimum. The greatest care was exercised to keep the aphids well nourished. The chief difficulty was with plants occasionally failing to thrive, and poor condition of the food-plants was soon reflected in increased numbers of winged forms. These cases were few, however, and were encountered in each set of conditions. It was believed by using large numbers that this factor of variation was largely eliminated, and the results under different conditions were comparable. When it became apparent that plants were failing the aphids were transferred to better ones as soon as possible, and the effect was thus minimized. None were discarded on account of poor nutrition. It was found that very young wheat plants, 6 or 8 to a pot, were most suitable. These usually furnished an abundance of food for the family of an aphid of this species, and the aphids could easily be seen and counted by rotating the pot.

This compound experiment not only tested the factors of parentage and temperature, but also furnished aphids for parents, in experiments testing the factors of nutrition and the effect of chemical treatment. These experiments were checked by the temperature and parentage experiment.

The results of the compound experiment are shown in Table I.

TABLE I. RESULTS FROM GENERATION CAGES.

Temperature	Parentage	No. Families Reared	Progeny			
			Alate	Apterous	Total	% Alate
80° F.	Alate	10	2	83	85	2.35
	Apterous	20	21	243	264	7.95
	Total of both	30	23	326	349	6.59
75° F.	Alate	7	1	49	50	2.0
	Apterous	12	16	208	224	7.12
	Total of both	19	17	257	274	6.20
72° F.	Alate	13	2	224	226	0.88
	Apterous	20	65	864	929	6.99
	Total of both	33	67	1088	1155	5.80
70° F.	Alate	5	0	23	23	0
	Apterous	9	2	61	63	3.17
	Total of both	14	2	84	86	2.37
65° F.	Alate	10	4	140	144	2.77
	Apterous	19	7	693	700	1.00
	Total of both	29	11	833	844	1.30
*62° F.	Alate	15	19	191	210	9.05
	Apterous	23	61	249	310	19.67
	Total of both	38	80	440	520	15.19

* Approximate; see explanation under "Effect of Temperature."

TABLE II. DATA OF TABLE I ARRANGED TO SHOW INFLUENCE OF GRANDPARENTS.

Grandparent	Parent	Progeny at						
		80°	75°	72°	70°	65°	62°	Average of all Temperatures
Apterous	Apterous	147 9.73	158 3.79	700 9.22	35 5.71	440 1.15	153 24.84	1633 9.24
Alate	Apterous	117 5.98	66 15.15	229 0	28 0	260 .77	157 14.52	757 6.07
Apterous	Alate	71 2.82	50 2.00	195 1.02	23 0	144 2.77	169 11.24	652 2.28
Alate	Alate	14 0	....	31 0	....	....	41 0	86 0

(In each case the upper figure given is the total number of progeny reared, the lower figure the percentage of this number that were alate.)

A number of experiments were performed on the influence of nutrition. While these will be explained in more detail later, it is necessary to refer to them here in their connection with the percentage factor. In all these tests, which varied in nature, nutrition was limited in some manner, while in the parentage and temperature experiment, nutrition was near the optimum.

TABLE III. SHOWING INFLUENCE OF PARENTAGE AND NUTRITION.

Parentage	Parentage and Temperature Exper.		Nutrition Experiments		Total of Both	
	Total No.	% Alate	Total No.	% Alate	Total No.	% Alate
Alate	676	4.14%	165	9.09%	841	5.25%
Apterous	2552	9.17%	674	60.80%	3228	18.06%

"Total No." refers to progeny in each case.

From the above results the writer concludes that winged agamic females of this species have a strong tendency to produce all apterous progeny, and that wingless females produce a variable percentage of alate progeny. When other conditions are favorable for production of wingless aphids, the progeny of both forms will approach 100% apterous (as in well-nourished aphids at 65° F., Table I). When other conditions favor production of alate forms, the percentage of these in the progeny of winged mothers will show only a slight increase. In a similar case percentage alate in the progeny of apterous mothers will show a considerable increase, and may approach 100% (see Table III). When both mother and grandmother were alate, no alate progeny were produced. When both mother and grandmother were apterous the percentage of alate offspring was higher in most cases than where the grandmother was alate and the mother apterous. However, no difficulty was experienced in rearing 35 successive apterous generations, and no preponderance of alate forms was noted in the offspring at any time.

EFFECT OF TEMPERATURE.

Ewing (6), in rearing *Aphis avenæ* (a name by which *Rhopalosiphum prunifoliæ* has been commonly known, according to Baker and Patch) observed that no winged aphids developed at 65° F., few at 70°, about 80% were winged at 80°, and all became winged at 60°. He was working to find the effect of long-continued parthenogenesis, and the observations on effect of temperature were made incidentally.

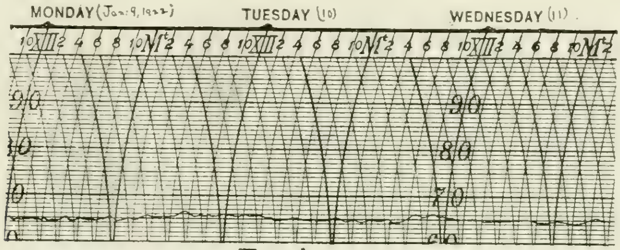

Fig 1

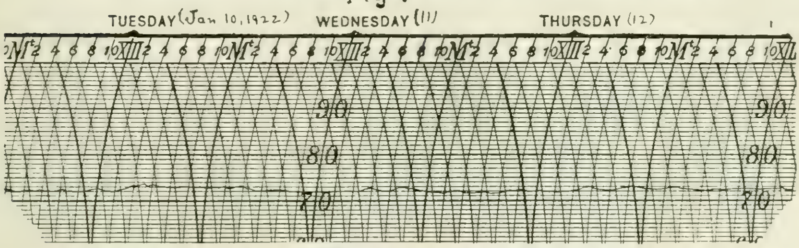

Fig 2

FIGURE III. 1 and 2—Facsimiles of typical temperature records taken during experiments.

In the writer's work the effects of temperature and parentage were made the subject of a compound experiment as described under the heading "Effect of Parentage." The rearing there explained was carried on in chambers, the air of which was conditioned by the apparatus described by Dean and Nabours (3). Since this article was written, a second chamber has been built, and the two can be kept at differing temperatures. The south chamber was kept at 80° from October 1, 1919, to January 15, 1920; at 75° from January 16 to February 23, 1920; and at 72° from December 21, 1921, to January 21, 1922. The north chamber was maintained at 70° from October 1, to March 20, 1919; at an average of 62° from November 21, 1919, to February 27, 1920; and at 65° from December 21, 1920, to January 21,

1922. The machine worked smoothly with few exceptions throughout the experiments, and wide fluctuations of temperatures seldom occurred. In the cases of all the temperatures except 62°, the temperature was near the desired point practically all the time, a straight line was sometimes described by the thermograph for several days, and the average was within a few tenths of a degree of the temperature sought. In the case of the average of 62°, it was attempted to maintain a temperature of 60°. This was found to be near the lower limit of the machine without special refrigeration, and with many warm sunny days, temperature often rose above 60°. Hence the air was allowed to become cooler than 60° at night. The average for the period was 62°. The fluctuations were wider than with the other temperatures and the minima were often below 60°. However, the results undoubtedly show the effect of temperatures lower than 65°. Duplicates of two representative temperature records are shown in Fig. III.

The results of the compound experiment are recorded in Table I. A condensation of Table I, showing the effect of temperature is shown in Table IV.

Table IV.

Temperature	% Progeny Alate		
	Of Alate Parents	Of Apterous Parents	Average of Both
80° F.	2.35	7.95	6.59
75° F.	2.0	7.12	6.20
72° F.	0.88	6.99	5.80
70° F.	0	3.17	2.37
65° F.	2.77	1.00	1.3
62° F.	9.05	19.67	15.19

The writer found that when other factors influencing wing-development were kept as nearly as constant as possible, the percentage of alate forms in the progeny of apterous parents dropped slowly from 80° to near 70°. In going lower the drop was more rapid, until at 65° the percentage was very low. At 62° the percentage of alate progeny showed a sharp increase.

In the progeny of alate parents, the percentage of alate was low and varied little at all the temperatures, except that at 62° a marked increase was shown. Since the progeny of apterous parents were more numerous than the progeny of alate parents, they have greater weight in the average of both.

No rearing in which all the progeny were counted was done at temperatures below 60°, but an apterous line was reared from March to December, 1921, 30 generations being produced. Average temperatures below 60° were experienced during several months, (55° in April, 59° in October, 44° in November and 36° in December) but no preponderance of alate offspring was noted and no difficulty was experienced at any time in maintaining an apterous line. Hence it seems unlikely that temperatures below 60° would show a considerable increase in the percentage of alate aphids, as might be deduced from the sharp increase in winged forms from 65° to 60°.

In Table V below, the writer's results are compared with Ewing's.

Table V.

Temperature	80° F.	75° F.	72° F.	70° F.	65° F.	60° F.*
Ewing's results, % Alate	80%	....	....	Few	0	100%
Writer's results, % Alate	6.59	6.20	5.80	2.37	1.3	15.19

* 60° in Ewing's experiments; average 62° in this work.

These results are seen to be parallel, though Ewing's percentages are much higher in three cases. In ordinary rearing, without careful attention to nutrition, a greater proportion of alate forms would occur than in the writer's experiments.

Nutrition is an important factor in wing-development in this species, and it was found necessary to control it carefully in order to test temperature. This is especially true because it proved to be a more potent factor than temperature in influencing wing-development. A comparison of the two factors, with explanation, will be found in Table X.

EFFECT OF NUTRITION.

Gregory (7) studied the effect of nutrition on wing-development in aphids. She used the pea aphis, called in her paper *Microsiphum destructor* Johnson. She starved the young during development, keeping them from food for periods of 8 to 24 hours at a time and a total of 40 to 60 hours during life. She found that few of the starved aphids developed wings; but when their young were reared, a large percentage became winged, even when well-nourished. However, when starved aphids became winged, their progeny contained few winged aphids. She concluded that starvation had little effect on the generation to which it was applied, but produced winged aphids in the succeeding generation.

In testing nutrition in this work the aphids were starved by confining them in small glass vials. The period of confinement was usually about 7½ hours each day. This was found to be the best length of time, as a longer period weakened the young aphids more than was desirable, and did not fit in with the other work. In one case, to be explained later, a 16 hour period daily was used. They were removed from the plants and replaced on them with a small brush. It was found that aphids must secure a firm footing on the plant when replaced. If they did not they would fail to establish themselves in their weakened condition, and few would survive. This was especially true of very young ones. Hence considerable time and careful work was required in the transfers, and, at the best, mortality was high. The young of winged parents proved more delicate under hardships than those of wingless parents, and a smaller proportion were successfully reared.

As it was found in several experiments that transfers did not affect wing-development, no special checks were employed in the nutrition experiments. The results from the temperature and parentage experiment were used to check these nutrition experiments. On account of the care and the numbers used, these results were more accurate than a special check could have been. Parents for the starvation experiments were taken from the progeny in the temperature and parentage experiment, hence their tendencies were known and readily checked from this experiment. At first it was attempted to use one parent in each nutrition experiment, but it was soon found better to use

several. They were placed on the plants and removed in a day or two, leaving a number of young, all of nearly the same age. It was soon noticed that a large percentage of aphids starved when developing became alate, especially if of apterous parentage. When this fact was established, some experiments were carried out to determine in what period of growth starvation was most effective in wing-development, and how many days of starvation were necessary to develop wings. These data are recorded in Table VI.

TABLE VI. EFFECT OF DIFFERENT PERIODS OF STARVATION.

Period Starved	Parent	Temperature	No. Tests	Progeny			Check % Alate
				Alate	Apterous	% Alate	
All through development	Apterous	80° F.	7	13	4	76.5	7.95
" " "	Apterous	70° F.	2	1	2	33.3	3.17
" " "	Apterous	62° F.	3	7	1	87.5	19.67
" " "	Alate	80° F.	3	1	4	6.7	2.35
" " "	Alate	75° F.	1	0	3	0	2.00
" " "	Alate	62° F.	3	1	5	2.00	9.05
First 4 days	Apterous	75° F.	1	1	7	12.5	7.12
" " "	Apterous	65° F.	1	0	9	0	1.00
" " "	Alate	75° F.	1	0	4	0	2.00
First 3 days	Apterous	80° F.	3	11	1	91.7	7.95
" " "	Apterous	65° F.	1	10	5	66.7	1.00
" " "	Apterous	62° F.	3	20	4	83.3	10.67
" " "	Alate	80° F.	3	0	9	0	2.35
" " "	Alate	62° F.	3	5	18	21.7	9.05
First 2 day	Apterous	75° F.	2	7	17	29.2	7.12
" " "	Apterous	72° F.	2	10	6	62.5	6.99
3rd and succeeding days	Apterous	75° F.	1	5	4	55.5	7.12
" " " "	Alate	75° F.	2	1	2	33.3	2.00
*4th and succeeding days	Apterous	80° F.	3	16	2	88.9	7.95
" " " "	Apterous	62° F.	3	7	1	87.5	19.67
" " " "	Alate	80° F.	3	4	16	20.0	2.35
" " " "	Alate	62° F.	3	1	7	12.5	9.05
2d day	Apterous	72° F.	1	0	11	0	6.99
2d and 3rd days	Apterous	72° F.	1	10	3	76.9	6.99
3rd and 4th days	Apterous	75° F.	2	6	7	46.1	7.12
*4th and 5th days	Apterous	75° F.	2	16	0	100.0	7.12
*4th day	Apterous	75° F.	1	3	3	50.0	7.12
2d and 3r dinstar	Apterous	72° F.	1	10	2	83.3	6.99
3rd and 4th instar	Apterous	72° F.	1	0	15	0	6.99

*The 4th day would usually include the latter part of the second instar, as the nymph would be about 72 hours old at the beginning of this instar.

In each case, the check from the corresponding parentage and temperature experiment is shown at the left. The young were starved about 7½ hours per day, except in the second of the two tests at 65°. In the first test with the ordinary starvation period no alate aphids were produced, although the effect showed in the progeny in the manner to be mentioned later. Hence in the second test a 16 hour period of starvation was used, and a high percentage of winged progeny produced, as shown in the table.

Starvation begun when aphids were about half grown caused many to become winged, but no evidence has been found that starvation begun after the second molt can cause development of wings.

In one case the soil of a cage was allowed to become dry, and of 20 aphids developing on plants thus deprived of moisture, 12, or 60% were winged, though the check was only 7% alate.

In a number of cases the aphids starved were retained until they produced young, and their young were reared. It was found that aphids which had been starved and had become alate produced nearly all apterous young, just as other alate parents, while aphids which had been starved, but remained apterous, invariably produced many alate young. This was true in all cases where starvation was applied, whether early or late in development. In some cases where the parent had been starved during only one or two days and remained apterous, most of the young were alate. In two cases adult apterous aphids were starved after maturity, having been well-nourished during development. In the first case one female, having been starved three days just after maturity, produced 18 young, of which 10, or 55%, were winged, the check being 7.12% alate. In the second case 3 females were starved during the three days after maturity, about 7½ hours a day as usual. The first day after starvation ceased, 19 young were produced, of which 18, or 94.7% were winged. The young for the next three days were discarded; the fourth day 15 young were produced, 11 or 73.3% being winged. The check was 6.99% alate. In all cases in which the young of starved parents were reared, these young were given ample nutrition. These data are summarized in Table VII.

TABLE VII. YOUNG OF STARVED PARENTS.

Parents (Starved during life)	Temperature	No. Tests	Progeny (well-nourished)			Check
			Alate	Apterous	% Alate	% Alate
Apterous	80° F.	5	12	27	30.8	7.95
"	75° F.	4	22	15	40.5	7.12
"	72° F.	5	79	13	85.9	6.99
"	65° F.	1	18	3	85.7	1.00
"	62° F.	3	6	5	55.5	19.67
Alate	80° F.	3	1	26	3.7	2.35
"	62° F.	1	0	16	0	9.05
Total Apterous		18	137	63	68.5	6.9
Total Alate		4	1	42	2.3	2.4

In cases where aphids were allowed to multiply for 2 or 3 generations, and overcrowded the plants of a cage, counts invariably showed high percentage of alate aphids. Some aphids were taken from such overcrowded plants, put on fresh plants, and their progeny reared with ample nutrition, with the results shown in Table VIII.

TABLE VIII. YOUNG OF OVERCROWDED PARENTS.

Parents (overcrowded during life)	Temperature	No. Tests	Progeny (not overcrowded)			Check
			Alate	Apterous	% Alate	% Alate
Apterous	80° F.	3	28	18	60.9	7.95
"	75° F.	1	6	1	85.7	7.12
"	62° F.	3	13	31	30.2	19.67
Alate	80° F.	3	1	26	3.7	2.35
"	62° F.	3	0	18	0	9.05

It was found, as might be expected from the data summarized in the last two tables, that poor nutrition showed its effect on one generation even after ample nutrition was supplied. In four of the temperatures used, in the generation and temperature experiment, the parents of the first generation were isolated from among poorly nourished aphids. The first generations results for these temperatures are not included in the totals of that experiment for this reason, but are given in Table IX for comparison and to show the effect of poor nutrition of parents.

TABLE IX. FIRST GENERATION RESULTS.

	80° F.		72° F.		70° F.		65° F.	
	No. Reared	% Alate	No. Reared	% Alate	No. Reared	% Alate	No. Reared	% Alate
First generation Apterous parent	17	70.6	61	34.4	0		32	53.1
Later generations Apterous parent		7.95		6.99		3.17		1.00
First generation Alate parent	13	7.7	4	75.0	14	7.1	19	5.2
Later generations Alate parent		2.35		2.0		0		2.77
First generation	30	43.3	65	36.9	14	7.1	51	35.3
Later generations Both		6.59		5.8		2.37		1.3

From the data cited a clear relation of the factors of nutrition and parentage as affecting wing-production can be traced.

No such relation can be found in comparing the factors nutrition and temperature. Scanty nutrition caused a high percentage of alate aphids at all temperatures at which it was tested. At 65°, as previously mentioned, starvation for the usual period did not cause the starved aphids to develop wings, but affected their progeny. When the length of the starvation period was increased a high percentage of winged aphids was produced at 65°. Table X shows the well-nourished aphids reared in the temperature and parentage experiment compared with those reared in the various nutrition experiments at similar temperatures. The latter were all limited in nutrition but at various stages for differing periods.

TABLE X.

Temperature	Generation Tests		Nutrition Tests	
	Total No.	% Alate	Total No.	% Alate
80°	349	6.59	220	39.5
75°	274	6.20	126	53.2
72°	1155	5.80	179	67.6
70°	86	2.37	3	33.3
65°	844	1.30	45	62.2
62°	520	15.19	166	36.1

(By "generation tests" is indicated the temperature and parentage experiment.)

The table illustrates how little the effect of temperature is shown under conditions of poor and varying nutrition, and suggests the importance of uniform nutrition in comparing temperatures.

It was found, in short, that limited nutrition early in life caused a large percentage of the progeny of apterous adults to become winged. The percentage of alate progeny was low with favorable nutrition. Of the young of alate parents few became winged even when starved. Aphids which had become winged under conditions of poor nutrition produced progeny which nearly all were wingless. Those which remained wingless in spite of such starvation during development produced progeny nearly all of which were winged, however well nourished. Apterous aphids starved after maturity also produced winged progeny. A high percentage of winged forms was produced by starvation at all temperatures tested, but greater difficulty was encountered in producing alate aphids at 65° than at other temperatures.

EFFECT OF CHEMICALS.

The fourth theory is that chemicals ingested affect development. Clarke (2) first demonstrated that young aphids feeding on cuttings with the lower end immersed in sand wet with a solution of a magnesium salt would develop wings. Woodworth (20) and Neills (11) continued this work, using *Nectarophora rosæ* L., as Clarke had done; Shinji (16) elaborated the work, using many compounds and several species of aphids. All the work was done with young aphids reared on cuttings, which were planted in washed sterile sand and watered with the solutions which it was desired to test. Among the substances found to be wing-producing were several magnesium salts, also silver nitrate, lead chloride, mercuric chloride, antimony chloride, silver sulphate and sucrose. Substances which did not develop wings were alcohol, acetic acid, tannin, urea, spring water, peptone, salts of alkali, and of earth metals, and alum. In general, the substances which did not develop an unusual percentage of winged forms are such as might occur in the soil, while those which produced winged forms are not usual soil constituents, or if present in quantity are toxic to plants. It was found that aphids which were not fed on the chemically charged cuttings until about half-way through

development would develop wings and that from 12 to 24 hours subjection to magnesium salts would cause wings to develop. A solution of magnesium sulphate as weak as $\frac{M}{1000}$ would produce the typical effect. Shinji minimized the effect of temperature on percentage of alate aphids developing, and suggested that the larger proportion of alate aphids observed on wilted plants may have been due to chemical changes in the sap obtained.

In this work it was first attempted to test the influence of chemicals by watering the soil of flower-pots in which wheat was growing with the solutions. In several tests this method failed to give results similar to Shinji's. The heavy metal salts used proved to be quite poisonous to the plants, stunning and nearly killing them, while the calcium and magnesium salts did not injure the plants noticeably. Later newly sprouted grains of wheat were planted in small jars in sterile sand, and watered with the solutions to be tested. With this method the sprouts failed to thrive in many cases, and the aphids made trouble by leaving the plants, so that few were reared.

The solutions were all $\frac{M}{10}$, except where the compounds were not soluble to that extent, when saturated solutions were used. Young were secured as in the nutrition tests, by placing several parents from the temperature and parentage experiments on the plants for a short time. The experiments with the first method were carried out at 80°, with the second method at 75° and 80°. The parentage and temperature experiment results at these temperatures furnished a check for them. A special check was also run for the second method. Table XI shows results for this method.

An effort was also made early in 1920 to rear aphids on wheat cuttings set in the solutions named. The cuttings died too soon for best results, few aphids were reared and no significant results were obtained. The heavy metal salts were very poisonous to the cuttings.

In 1921 and 1922 the time available was much shorter, and only magnesium sulphate was tested. This was done in two ways: aphids were reared on cuttings as before, and on seedlings growing in Pfeffer's solution, to which the magnesium salt had

TABLE XI. RESULTS OF CHEMICAL TESTS (1919–1920).

Chemical	Plants in Soil			Sprouts in Sand			Total	
	No. Tests	Alate	Apterous	No. Tests	Alate	Apterous	Alate	Apterous
H^2O (Check)	None			5	6	8	6	8
ZnSO4	4	11	23	5	0	2	16	25
CuSO4	4	5	23	5	7	26	12	49
$PbC_2H_3O_2)_2$	4	3	27	5	0	0	3	27
$Mg(NO_3)_2$	4	2	22	5	0	2	2	24
$Mg(NO_3)_2$ with excess of $Ca(NO_3)_2$	4	4	12	5	0	0	4	12
$MgCL_3$	4	7	13	5	8	19	15	32
$MgCl_2$ with excess of $CaCl_2$	4	6	5	5	14	16	20	21

(The numbers shown under "alate" and "apterous" are the number of aphids reared).

been added. In the latter case the wheat was sprouted in wet sand, washed, and transplanted into the bottles of Pfeffer's solution, in the manner described by McColloch (10). Magnesium sulphate was added to the solution in quantity sufficient to give a concentration of $\frac{M}{10}$ of this salt, while unmodified Pfeffer's solution was used in the check. Apterous aphids were placed on both, allowed to reproduce for a day or two, and their progeny reared. The cuttings used were stems of wheat about six weeks old. They were placed with the lower end of a $\frac{M}{10}$ magnesium sulphate solution, and others placed in tap water as a check. Apterous parents were supplied as with the plants in Pfeffer's solution. The young were transferred to plants in ordinary cages after living on the cuttings two days, as the cuttings did not last well. It was difficult to maintain good nutrition with this method. Table XII shows the results in 1921 and 1922.

TABLE XII. RESULTS WITH CHEMICALS IN 1921–1922.

Aphids Fed on	No. Tests	Aphids Produced			
		$MgSO_4$ Solution		Check	
		Alate	Apterous	Alate	Apterous
Plants in Pfeffer's Sol.	3	18	20	8	41
Cuttings in Water	2	15	6	9	9

The experiments were all carried on at 72%, and the results from the compound experiment at this temperature, with apterous parents, from an additional check.

The results obtained by Shinji and others with chemicals can evidently be duplicated with this species, though the wheat plant is by nature very difficult to use in such experiments. Plants rooted in soil or sand failed to give results similar to Shinji's. This was at first ascribed to selective absorption, and it was thought that rooted plants would not give the results secured with cuttings. However, magnesium sulphate has caused the development of winged aphids on rooted plants growing in Pfeffer's solution. The writer now believes the failures with plants in soil and sand, to be due to a fixing or adsorption of the chemicals by the soil. The Pfeffer's solution evidently permits the plants to take up enough chemical to affect the aphids.

In short, when wheat plants growing in Pfeffer's solution, and wheat cuttings in water were subjected to magnesium sulphate solution, a large proportion of young aphids of this species feeding on them became winged. Such results could not be produced when rooted plants in soil or sand were watered with solutions of magnesium salts or other toxic chemicals.

The writer believes the results secured by Shinji and others to be too abnormal to explain production of winged aphids in nature. Shinji stated a belief that the development of winged aphids on wilted plants commonly observed, was due to chemical changes in the plant sap. However, the writer obtained a large percentage of winged aphids on vigorous plants by removing them apart of each day during development. Changes in the sap would not be a factor in this case. The results with chemicals, however, are interesting in account of the striking

effect of the compound, because of the results with several species correspond closely, and because Shinji showed that the wing-developing factor was effective if applied when the aphids were nearly half-grown. The last two reasons are especially important from the standpoint of this paper.

OTHER OBSERVATIONS.

No other factors important in production of winged aphids have been observed by the writer. The accepted life-history of a number of aphid species indicate that many writers believed the cyclic factor important—that is, that numerous winged forms appeared in certain generations, counting from the stem mother. Haviland (8) after experimenting with other theories, concludes the cyclic factor to be one of the most important with the currant aphis (*Mysius ribis* L.). In the writer's work no results were obtained which would substantiate this view. Though individual families varied widely in proportion of alate aphids no connection with any given generation was traceable.

Baker (1) suggests that percentage of winged forms varies in different strains, and may be a heritable character. The two strains used by the writer at different times showed no perceptible difference. However, these were obtained from the same environment, and might have been identical. To test this factor, it would be desirable to have the aphids reproducing sexually, so that the origin of the strains, and their development from the first, could be observed.

It is interesting to compare different species of aphids with regard to the factors studied. The pea aphis, *Illinoia* (*Macrosiphum*) *pisi* Kalt, behaved similarly to *Rhopalosiphum prunifoliæ* with respect to parentage and nutrition, when observed in a preliminary way. Gregory also worked with the pea aphis; Shull with *Macrosiphum solanifoliæ;* and Ewing with the species used by the writer. Shinji secured closely corresponding results with several common species. The rather meager data so far secured indicates that the factors for wing-development work out in about the same manner in all the common species tested.

The writer has not been able to take up the factors influencing the development of males and oviparous females. As already stated, the sexes did not appear in these experiments under any conditions provided, though some have been seen in

the field. Shull (18) has indicated a belief that the sexes appear as part of a cycle. Phillips (14) has recorded valuable data on *Macrosiphum granarium* Kirby, stating that cold weather appeared to favor the development of the sexes, while high temperatures in the insectary prevented their appearance. Uichanco (19) believed that in the more primitive forms the sexes appear as part of a cycle, while in the specialized forms the development of the sexes is brought about by cold and in some cases by lack of food. In the rotifers which, like the aphids, reproduce both parthenogenetically and sexually, Shull (17) has worked out the factors bringing about the change from the first to the second method of reproduction. In this case, however, nutrition is the controlling factor, which is evidently not true with the aphids. With the species used by the writer, cold, hunger, or long-continued parthenogenesis did not produce the sexes and artificial colonization on the winter food-plant was ineffective. Just what combination of factors will produce the sexes is yet to be found. This subject has been even less studied than the production of winged forms.

SUMMARY.

Rhopalosiphum prunifoliæ Fitch, a species of aphid widely distributed on grain and well adapted for the work, was used in these experiments. Development occupies about 7 days, the total life nearly a month. From 25 to 75 young are usually produced by a female.

Parentage was tested by rearing the progeny of individuals, temperature by running these tests in two constant-temperature chambers, 80°, 75°, 72°, 70°, 65°, and 62° F. being tested. This formed a compound experiment. Nutrition was tested by starving young aphids and rearing them. Their progeny was sometimes reared also. Starvation was effected by confining the insects away from food a certain number of hours per day. The influence of chemicals was tested, by rearing aphids on both rooted plants and cuttings in the chemical solutions. Considerable difficulty was encountered in these tests. Wheat was used as a plant food in all cases.

Alate females produced all or nearly all apterous progeny; apterous females produced a greater or less proportion of alate progeny depending on other factors. The proportion of winged forms produced at 65° was lower than at either higher or lower

temperatures. A large proportion of aphids starved or overcrowded early in development became winged, as did the progeny of those remaining wingless in spite of poor nutrition. The progeny of alate aphids were usually apterous even when nutrition was poor. Greater difficulty was encountered in producing alate aphids by starvation at 65° than at other temperatures. Chemicals used tended to produce winged aphids in cases where the difficulty of the methods did not render a comparison impossible. Wing-production factors appear to be ineffective unless applied before the second molt. Other factors, such as the cyclic factor and the factor of varying strains, mentioned by some workers, were not apparent in these experiments. The writer was unable to produce the true sexes or find the factors causing their appearance.

The chemical factor, though interesting, appears to the writer to be too abnormal to be important in nature; the factors of nutrition, parentage and temperature are all important, and must all be considered in experiments planned to test any one of them. Definite relations exist between them in their effect on wing-development.

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THE GENUS PHILORNIS— A BIRD-INFESTING GROUP OF ANTHOMYIIDÆ

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The first contribution to a knowledge of this group was made by Macquart (1853, 657), when he described *Aricia pici* from Santo Domingo, recording the larva as a subcutaneous parasite of a woodpecker (*Picus striatus*), apparently a full grown bird.

Loew (1861, 41) next described *Hylemyia angustifrons* from Cuba, and Jaennicke (1867, 377) *Mesembrina anomala* from the same island, both without any data about larval habits.

Townsend (1895a, 79 and 1895b, 173) described a parasite of a nestling bird from Jamaica, under the name *Mydaea spermophilæ*, the host being Spermophila sp., probably *bicolor* Linn. The larva was under the skin of the nestling. Busck (1906, 2) furnished important additional information on *pici* from personal observations made in Santo Domingo. Some of his material is in the National Museum.

Macquart, Townsend and Busck all mention a cocoon made by the larva, which in normal conditions appears to be covered with grains of dirt.

The genus Philornis was erected by Meinert (1889, 304) with the single species *molesta*, new, known only in the larval state from nestling birds in Brazil, a subcutaneous parasite. Brauer and Bergenstamm (1894, 568) included the species in a list of parasitic Diptera, but added the unlucky suggestion "(Lucilia dispar?)." The latter fly belongs to the family Calliphoridæ. They erroneously gave as the host a European bird, which was mentioned by Meinert in a different connection.

Bezzi (1908, 545) followed the suggestion of Brauer and Bergenstamm and made Philornis a synonym of *Protocalliphora azurea*, the common European bird parasite, of which *Lucilia dispar* is also a synonym.

Neilsen (1911, 195) had received larvæ, puparia and adults of a nestling parasite from Concepcion, Argentina, which he

identified as *Mydaea anomala* Jaennicke; later (1913, 251) he received additional material in another species from Argentina, and on comparing the type of *anomala* found the latter to agree, so he gave the first species a new name, *torquans*. He figures the larval structures in both species.

Townsend (1919, 542) makes both Philornis and Protocalliphora synonyms of Phormia, continuing the mistake of Brauer and Bergenstamm.

Bezzi (1922, 29-46) gives an admirable summary of the literature of non-pupiparous Diptera infesting birds. In this paper he decides to accept Philornis provisionally as the valid generic name for the Anthomyiid group, including *Mydaea pici* Macquart, *torquans* Neilsen, and *spermophilæ* Townsend. He places *molesta* and *anomala* (of Neilsen, 1913) as synonyms of *pici*.

Malloch had the year before (1921, 41) proposed the genus Neomusca based on a cotype of *Mydaea obscura* Van der Wulp (Biologia, Dipt., II, 317, 1896), from Yucatan. He also had a specimen from Texas. No information was at that time available on the habits of the species, and Malloch did not connect it with the *pici* group. Recently, however, specimens of *obscura* were sent to the National Museum for identification by F. C. Bishopp, who reared them at Uvalde, Texas, from puparia found in the nest of the mockingbird. On comparison with undoubted *pici* from Santo Domingo in the National Museum, they were found to be congeneric according to the characters assigned by Malloch. The chief of these characters is the presence of a tuft of coarse hairs on the lower part of the declivity which lies between the root of the wing and the basal lateral angle of the scutellum, just above the line where the calypter joins the body; the genus is also distinguished by having the calcar wanting, pteropleura hairy, prosternum bare, arista long plumose and the third and fourth veins divergent, the latter a little bent forward at tip.

The question arises whether the genus Neomusca, based on good adult characters, should be displaced in favor of the older Philornis, based only on a few characters of the larva, but with its adult not certainly known. To answer this requires a consideration of all the facts at present known which serve to connect the two.

The principal character given by Meinert is the structure of the stigmal plate, or posterior spiracle, of the larva, which he figures (copied in my Fig. 1). This shows three simple slits in the shape of a U or V. Neilsen was fortunate enough to obtain larvæ, puparia, and adults of the two species in this group. In his two papers he figures the larval stigmal plates of both (*torquans*, adapted in my Fig. 2; and *anomala*, Fig. 3). *Torquans* has almost identically the same slits as *molesta*, but Neilsen (1911, 207) finds slight differences in the anterior spiracle and perhaps in the pharyngeal sclerites which seem to suggest a specific difference. *Anomala* has three slits, but they show

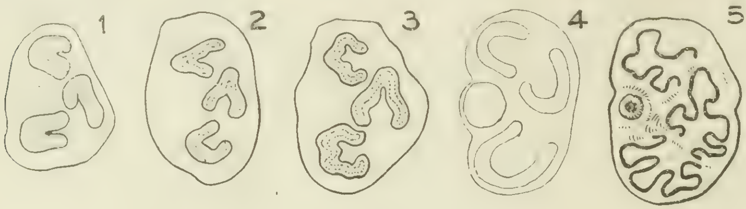

FIGURE I.

1. Philornis molesta Meinert, right stigmal-plate of third-stage larva. Copied from Meinert.
2. Philornis torquans Neilsen, same organ, copied without the shading from Neilson.
3. Philornis anomala Jaennicke, same organ, copied without the shading from Neilsen.
4. Philornis obscura Van der Wulp, right stigmal plate of puparium. Sketched by the author.
5. Philornis pici Macquart, right stigmal plate of puparium. All except No. 4 drawn by Chas. T. Greene.

traces of sinuosity and probably indicate another species. According to Neilsen's correspondent Mogensen *anomala* "before pupating made a cocoon of earth by means of a bright liquid which later on changed into a white substance." Torquans did not do this.

Returning to *obscura*, the type of Neomusca which infests the mockingbird in Texas, we were fortunate enough to get three puparia of Mr. Bishopp, from which he reared the flies. They agree with those of *torquans* in the stigmal plates (Fig. 4) except that the middle slit is almost reversed, and the upper and middle are more rounded. Here we are comparing the plates of a third-stage larva with those of a puparium, but we should expect little difference in these stages. Two of the *obscura*

puparia are enclosed in a dense mass or cocoon of downy feathers, indicating that pupation takes place in the nest, which is corroborated by Bishopp.

Our single puparium of *pici*, collected by Busck, has larger stigmal plates (Fig. 5) with decidedly sinuous slits; it resembles in this respect Neilsen's figure of *torquans*, but the slits are still more sinuous. In both this and the preceding, the posterior end of the puparium has a deep concavity, smooth inside, in which the stigmal plates are situated; and the same is mentioned by Neilsen for *torquans* and *anomala*, but he does not figure the plates. This concavity occurs also in the third-stage larva of *torquans*, according to Neilsen, but not in the earlier stages.

It thus appears, on comparison of the puparium of *obscura*, type species of the genus Neomusca, with puparia and larvæ of South American Anthomyiids that are almost certainly congeneric with *molesta*, type of Philornis, that in addition to similarity of habits there are structural characters which unite the species into a fairly homogeneous group that may well be assumed to be a single genus. I therefore conclude that Professor Bezzi's action is justified in adopting Philornis for the group; while Malloch is to be given credit for discovering new and valuable adult characters which define the genus, it would seem that his Neomusca is almost certainly a synonym of Philornis.

Stein (1918, 212) has redescribed the type of *anomala*, and has fortunately given enough characters to place it as a distinct species, not as formerly supposed a synonym of *pici*. However, when I asked Mr. Nathan Banks to compare Loew's type of *angustifrons* in the Museum of Comparative Zoology with the data in the present paper, he reported that it has the characters of *anomala*. Both species are described from Cuba and the synonymy may be regarded as fairly well established. I therefore use the older name *angustifrons*.

The distinction between *torquans* and *anomala* of Neilsen is very slight in adult characters; it seems to me that his first species, later called *torquans*, comes nearest to agreeing with Stein's description.

Spermophilæ was identified by Johnson from Jamaica (Bull. Amer. Mus. N. H., XLI, 1919, 440). He very kindly submitted his specimen, a female, for my examination. It is

not congeneric with the species under discussion, although it has several of the characters. It was not reared, and it has black palpi; I doubt if it be the true *spermophilæ.*

Omitting *torquans* and *spermophilæ* from further consideration for the present as unidentifiable without additional characters than those of the descriptions, the material in the National Museum falls into *pici*, *angustifrons* and *obscura*, which may be separated by the following table:

TABLE OF SPECIES.

Males.

Hind tibia on outer hind side with 3–4 short but stout spines near middle; front at narrowest .05 of head width, the median stripe almost or quite obliterated. *angustifrons* Loew.

Hind tibia on outer hind side with a single bristle at middle. Eyes contiguous; hind femur on outer lower edge with only small bristles except 2–3 near apex. *pici* Macquart.

Eyes separated, front at narrowest .09 to .11 the headwidth; hind femur on lower outer edge with a row of 8–9 stout spines, beginning near base............ *obscura* Van der Wulp.

Females.

Hind tibia on outer hind side with 3–4 short but stout spines (not seen)........ *angustifrons* Loew

Hind tibia on outer hind side with only one spine at middle. Abdomen subshining, with a faint bluish cast.....................................*pici* Macquart.

Abdomen opaque pollinose, with a trace of tesselation.....*obscura* Van der Wulp.

MATERIAL EXAMINED.

Philornis pici Macquart.

One female reared by Busck from *Dulus dominicus* in San Francisco Mts., Santo Domingo; puparium of same fly; piece of wing of same host bird, with hard swelling from which larva has emerged; one male, Higuito, Costa Rica (Pablo Schild); one female, Port of Spain, Trinidad, B. W. I., bred from larva on head of bird (Urich). I place the male here because Macquart's figure shows the eyes distinctly contiguous.

Philornis angustifrons Loew.

One male, Higuito, Costa Rica (Pablo Schild); one male, Berbice, British Guiana, 3–10–12, "bred from cutaneous tissue of a bird," "Twa-tina parasite." Through Robert Newstead. These agree well with Stein's description of *anomala.*

Philornis obscura Van der Wulp.

One male, two females, Uvalde, Texas, with three puparia, from nest of mockingbird (Bishopp, No. 6107); one male,

Chosica, Peru, 3000 ft., on foliage, IV–21–1914 (C. H. T. Townsend). The Texas male has the front .09 of the head-width, the Peruvian one is .11. One female has the legs dark just as described by Townsend for *spermophilæ*, which prevents me from recognizing the latter on leg color as Bezzi has done. The Texas material is identified by Malloch, but not directly compared with Van der Wulp's cotypes, which are now in the Illinois Natural History Survey Collection at Urbana, Illinois.

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THE GENUS PHLEPSIUS IN NORTH AMERICA (HOMOPTRA)

By Herbert Osborn and F. H. Lathrop.

The Genus Phlepsius was established by Fieber in 1866 and has as a haplotype the European species *intricatus*. It includes a rather small number of old world species but the number of American forms referred to the genus has been increasing rapidly until now there are more than 70 American species from North of Mexico and a number of species from Mexico, Central and South America.

A number of species have had general recognition although some have been referred to other genera. The first American form described was *irroratus* Say (1831) and except for a few species by Fitch (*fulvidorsum* 1851) Walker (*solidaginis* 1851) and Uhler (*excultus* 1877) but little attention was given to the group until the monograph of the genus by Van Duzee in 1892. In this paper Mr. Van Duzee gave a key to species, describing a number of new forms, making a total list of seventeen species. Of this original list *strobi* as identified by Van Duzee has been referred to *Eutettix* but *costomaculatus* has been included. Since Van Duzee's paper a number of species have been recognized and described by Osborn, Ball, Baker, Crumb, Sanders, DeLong and Lathrop. Inasmuch as this accumulation, with the widely scattered descriptions has made the identification of species difficult and several new species are in hand, making a total of over 80 species, it seems that a key to the known forms with diagnostic descriptions accompanied by outline figures of the genitalia will be useful in further work on the group. Undoubtedly additional species will be found upon careful collecting, particularly in localities as yet unworked and recognition of species will be facilitated by such a paper.

As originally established the genus character was based on the wide vertex and irrorate elytra. The type species possesses a distinctly sharp edged vertex, but evidently this character cannot be counted as of generic value since so many species

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which appear strictly cogeneric vary widely in the acuteness of the edge between the vertex and front. As limited in the present paper the genus includes forms having a single cross nervure, but with more or less distinctly marked irrorations or reticulations within the elytral cells. The vertex is flat or sloping, in a few instances upturned, without transverse furrow; front sloping, straight or convex in profile, sometimes concave on base and decidedly oblique to axis of body. The clypeus is usually more or less widened at apex and the loræ large, approaching margin of face. The elytra are longer than the abdomen, the wings generally fully developed and no species are as yet known of dimorphic short-winged forms. On the whole they are shorter and blunter than species of *Thamnotettix* or *Chlorotettix*. Structurally they resemble *Euscelis* but usually can be separated from this genus by the general fascies and the more oblique head with ocelli nearer the eyes.

Ball has published on Mexican and Central American species and proposed divisions to sub-genera. His basis of division is adopted in the main in our arrangement of species, but in order we have placed the *utahnus* group first, and *majestus* group last.

Most of the species are of grayish or brownish color, however, when a distinct color occurs this is quite constant. The more distinct specific characteristics are the shape of the vertex and the distribution of pigmentation of the elytra, but the most positive character is in the genitalia, both sexes ordinarily possessing a distinct genital structure. In general the size for each species is quite uniform. As a rule the males and females agree very closely in shape and markings and there is little difference in size, the males usually somewhat smaller. In the female the characters consist of distinct sculpturing of the last ventral abdominal segment. This varies greatly in details of hind margin. In the male the shape of the valve, but especially the outlines of plates afford reliable characters.

The genus is distributed in North America throughout the nearctic and in the neotropic region but the greatest known abundance occurs in the Mississippi Valley and it would seem that within this faunal area there has been the greatest opportunity for evolution of different forms. However, the Atlantic and Gulf Coast Region and the southwest states present a considerable array of species having limited distribution. A few

have a very wide distribution; *irroratus* occurs from Maine to Washington and south to the Gulf; *apertus* has a northern range from Atlantic coast to Rocky Mountains; *majestus* from New Jersey to Texas; *superbus* has a southern range from North Carolina to California. Most of the species, however, have limited range so far as determined and are adapted to certain ecological conditions or to restricted food plants. They may range from bogs of the northeast to arid plains of the southwest, but each species is adapted to distinct environmental conditions. In food plants they show wide choice, but most feed on grasses, or low herbs in fields, meadows and grassy plains. But very few have been studied for life history and there is large opportunity for careful work in determining details of habits, life history and ecology.

The authors have worked together on descriptive matter, the senior author especially on the key and technical descriptions and the junior author is especially responsible for the figures of the details for the species, which have been drawn to a common scale and as far as possible from type specimens and both descriptions and figures carefully compared and verified jointly. We have omitted all synonomy and bibliographic references except such as have appeared since the publication of Van Duzee's Catalogue. To have given them in such detail as to have been of value would have greatly extended this paper and it seems fair to assume that any one making use of this paper will have access to Van Duzee's indispensable catalogue.

MATERIAL AVAILABLE.

The materials examined include species collected for many years by the Senior author, collections in South Carolina and Oregon by the Junior author. Also collections from National Museum and Bureau of Entomology. These include many types of Osborn and Ball species as well as for species described by Ball, DeLong, Lathrop and Sanders and DeLong. We are especially indebted to Mr. E. P. Van Duzee, Dr. E. D. Ball, and Messrs. Sanders and DeLong for the opportunity to examine specimens in their collections, including much type material which has made possible the inclusion of many figures that would otherwise have been impossible. We are indebted to the South Carolina Experiment Station for the use of figures from Bull. 199 on Cicadellidæ of South Carolina by F. H. Lathrop.

KEY TO THE NORTH AMERICAN SPECIES OF PHLEPSIUS.

Pronotum with lateral margins very short, carina faint or obsolete..........1
Pronotum with lateral margins distinct, carina well marked............10
1. Vertex angulate, elytra densely marked..................................2
Vertex rounded or faintly angulate, elytra sparsely obscurely marked......6
2. Markings varied with tawny and orange........................*tinctorius*
Markings uniform gray, white and black or fuscous.......................3
3. Elytral pattern irregular...4
Elytral pattern uniform, with dense ramose lines..........................5
4. Small, vertex with minutely dotted picture...........*utahnus and arizonus*
Larger, vertex with indefinite picture, oblique stripe on clavus..*pulchripennis*
5. Larger, length 4 to 4.5 mm. (Fla.)..............................*floridanus*
Smaller, 3.5 mm. (Me.)..*graniticus*
6. With distinct spots on elytra and in the costal cell.......................7
All spots on the elytra faint or obsolete..................................9
7. Vertex short, rounded...*costomaculatus*
Vertex longer, subangulate..8
8. Over 4 mm...*attractus*
Less then 4 mm...*loculatus*
9. With scattered small dots on vertex..............................*denudatus*
With star-shaped spots on vertex..................................*stellaris*
10. Carina on margin of pronotum very short, less than half short diameter of eye..11
Carina on margin of pronotum longer, more than half short diameter of eye, head narrower than pronotum......................................54
11. Front margin of head rounded or acute at apex only.......................12
Front margin of head thin, acute, front concave below vertex..............46
12. Head rounded in front, not or very faintly angulate......................13
Head angulate, vertex longer on middle than next the eye..................29
13. Vertex very short, margins parallel or slightly longer at middle..........14
Vertex perceptibly longer at middle than at eye...........................25
14. Margins of vertex very blunt, rounded or scarcely angled to front........15
Margins of vertex more angulate...16
15. Vertex short very sloping to front without ocellate spots............*latifrons*
Vertex less sloping, two ocellate spots on hind margin.............*maculosus*
16. Costal cell without black spots..17
Costal cell with black spots..21
17. Small, 5 mm. long...*pusillus*
Larger, over 5 mm. long...18
18. Dark fuscous, 6 mm..*fuscipennis*
Light tawny...19
19. Over 6 mm., scutellum yellow, not concolorous......................*tigrinus*
Scutellum concolorous tawny or brown......................................20
20. Vertex longer at middle than at eye, elytra with fine lines........*turpiculus*
Vertex scarcely longer, elytra minutely dotted.................*micronotatus*
21. Elytra concolorous with head and pronotum.................................22
Elytra much darker than head and pronotum..........................*collitus*
22. Front black at base...*nigrifrons*
Front pale with broken black arcs...23
23. Larger, female 7.5 mm.–8 mm............................*vanduzei, pallidus*
Smaller, length of female 7 mm. or less...................................24
24. Light gray, female 6.5 mm.; male 6 mm.............................*cinereus*
Dark gray. Female 7 mm.; male 6.25 mm..............................*cottoni*
25. Apex of vertex with dark spots....................................*lascivius*
Apex of vertex not marked with conspicuous black spots....................26
26. Smaller...27
Larger..28
27. Vertex scarcely longer at middle than at eye..........................*altus*
Vertex nearly half longer at middle than at eye......................*collinus*

28. Female segment long, deeply incised, male plates triangular.........*incisus*
Female segment short, four lobed, male plates spoon-shaped.........*tubus*
29. Not produced nor decidedly acute at apex of head........................30
Head decidedly produced at apex and acute, rounded toward ocelli........43
30. Female ventral segment strongly dentate, male plates constricted at middle...*irroratus*
Female segment not strongly dentate, male plates less constricted........31
31. Vertex but little longer at middle than at eye..........................32
Vertex distinctly longer at middle than at eye, sometimes twice as long....33
32. Female segment truncate...*truncatus*
Female segment lobate at lateral angles...........................*lobatus*
33. Elytra uniformly irrorate...34
Elytra not uniformly irrorate, maculate over entire surface.......*maculellus*
34. A distinct white dot on one or both claval veins at tip.....................35
White dot at end of claval veins faint or wanting...........................40
35. Both claval veins with white dots at apex.................................36
Hind claval vein only with conspicuous white dot at apex..................38
36. Vertex shorter, less angulate...*tenessa*
Vertex longer, more angulate..37
37. Larger, 7 to 8 mm...*rileyi*
Smaller, 6 to 6.5 mm.....................................*torridus, brunneus*
38. Elytra not banded, irrorations fairly ever..............................*texanus*
Elytra more or less distinctly banded..39
39. Vertex less angular (E. U. S.)..*apertus*
Vertex more angular, longer, (Pacific Coast)......................*apertinus*
40. Head, pronotum and elytra uniformly colored......................*carolinus*
Head and pronotum much lighter colored than elytra........................42
41. Vertex nearly twice as long at middle as at eye................*fulvidorsum*
Vertex less than twice as long at middle as at eye..........................41
42. Elytra nearly uniformly dark..........brown, *particolor;* black, *eburneolus*
43. Elytra broadly banded; darker on posterior half..................*tullahomi*
Elytra with narrow distinct bands..44
44. Head, pronotum and elytra nearly concolorous..*fastuosus, slossoni, lippulus*
Head and pronotum rufus or tawny, elytra gray..............................45
45. Vetrex produced, half longer at middle..............*fulviceps, franconianus*
Vertex less produced, one-third longer at middle.......................*strobi*
46. Apex of head produced and sharp edged...........................*punctiscriptus*
Apex of head not specially produced but thin, sharp edged, the thin edge extending to near the ocelli..47
47. Vertex very short with fore and hind margins parallel...............*planus*
Vertex longer, longer at middle than at eye..................................48
48. Vertex not more than half longer at middle than at eye 49
Vertex more than half, sometimes twice longer at middle than at eye.....50
49. Larger, 7 mm. or more...*solidaginis*
Smaller, 6 mm. or less.........flecked with red, *josea;* without flecks, *nudus*
50. Larger, 9 mm. gray or light tawny.................................*nebulosus*
Smaller, usually dark gray or fuscous.......................................51
51. Broad, with rather blunt-headed appearance................................52
More slender with more pointed head...............................*occidentalis*
52. Vertex nearly twice as long at middle as at eye...........................53
Vertex about one-half longer at middle than at eye...................*bifidus*
53. Vertex nearly flat...*ramosus*
Vertex sharply upturned...*tenuifrons*
54. Head wide, flattened, scarcely narrower than pronotum..........*extremus*
Head narrower, distinctly narrower than pronotum..........................55
55. Front wider at base, vertex wider, head but little narrower than pronotum..56
Front long and narrow, vertex narrow, head much narrower than pronotum..68
56. Sutural margin of elytra uniform without distinct light areas.............57
Sutural margin of elytra with distinct light areas...........................63

57. Elytra uniformly and finely irrorate....................................58
    Elytra coarsely reticulate or spotted....................................62
58. Length 7 mm. Female segment excavated to base (Mex.)..........*eugeneus*
    Length less than 7 mm. Female segment not excavated to base............59
59. More slender species..60
    Robust species..61
60. Front with light arcs on dark ground...........................*superbus*
    Front with dark arcs on light ground..........................*rufusculus*
61. Vertex short, but little longer at middle than at eye..........*cumulatus*
    Vertex longer, one-half longer at middle than at eye............*umbrosus*
62. Vertex depressed. Length 6 mm. (U. S.).......................*areolatus*
    Vertex convex. Length 6.75 (Mex.)..............................*mexicanus*
63. Vertex, pronotum and scutellum light, elytra dark...............*excultus*
    Vertex pronotum and scutellum concolorous with elytra..................64
64. Elytra with coarse distant spots..65
    Elytra finely and evenly irrorate.......................................66
65. Elytra white coarsely spotted with black (N. C. to Fla.)........*distinctus*
    Elytra pink, smaller, (Oregon).................................*annulatus*
66. Vertex flat, or with depressed areas....................................67
    Vertex convex, smaller species, elytra not flaring.................*ovatus*
67. Vertex with distinct light line between ocelli. (Mex.)...........*hosanus*
    Vertex with less distinct line between ocelli, and the basal part more or less dotted. (U. S.)..........*notatipes, graphicus, decorus*
68. Smaller species, 7.5 mm. or less..69
    Larger species, 8.5 mm. or over...75
69. Larger, 7.5 mm., vertex banded..70
    Smaller, 6 mm. or less, vertex not banded...............................71
70. Paler...*spatulatus*
    Darker..*sabinus*
71. Elytral markings distinct, color..72
    Elytral markings faint, color light ashy................................74
72. Length 4 mm...*denticulus*
    Length about 6 mm...73
73. Male pygofers twice as long as plates.........................*neomexicanus*
    Male pygofers half longer than plates..........................*incurvatus*
74. Length 6 mm..*cinerosus*
    Length 4 mm..*delicatus*
75. Vertex flat with a narrow light margin (Mex.)....................*elongatus*
    Vertex convex with a broad light margin.................................76
76. Vertex twice wider than long, female segment with a shallow notch......77
    Vertex narrower, female segment with a deep narrow slit (Mex.)..*handlirschi*
77. Pale tawny, female segment with a shallow notch (Mex.)...........*hebræus*
    Dark tawny, female segment with a narrow notch, toothed, (U. S.)..*majestus*

NOTE.—Phlepsius *marmor, hemicolor* and *palustris*, described and figured by Sanders and DeLong, Proc. Ent. Soc. Wash., vol. 25, pp. 152-3, issued Nov. 26, 1923, are not included, as their publication came after our paper was in type. *Marmor* is near *graphicus* Ball, *hemicolor* near *fulvidorsum* and *palustris* seems to fall near *pianus*. *Phlepsius atropunctatus* DeLong, Hemip. Conn., p. 131 (1923), is *Fieberiella flori*, Stal. an European species evidently recently introduced, and taken also near Boston, Mass., and Rutherford, N. J. *Phlepsius dentatus* Baker is referred to *solidaginis* Walker.

Sub genus Dixianus Ball

Phlepsius tinctorius Sanders and DeLong. (Pl. XXV, Fig. 1).
Annals Ent. Soc. Am., Vol. XII, p. 235.

Head scarcely wider than pronotum, sub-angulate, vertex depressed on middle, nearly one-half longer at middle than next the eye, margin obtuse, front convex; pronotum with the lateral margins short, not carinate. ♀ ventral segment one-half longer than penultimate, simple and truncate behind, male valve small, angular, plates elongate triangular, compressed, not reaching tip of pygofer. Dark fulvous, vertex with the disk fulvous, anterior border and two spots on posterior margin yellowish, bordered with black. Pronotum fulvous with blackish irrorations, scutellum orange, with a black sutural spot, spots on lateral margin and apex ivory white. Elytra tawny or fulvous with whitish spots on discal and apical cells, veins and reticular lines black. Face black with small yellow dots. Length, ♀, 5.5 mm.; ♂, 5 mm.

New Jersey, on *Aralia spinosa.*

Phlepsius utahnus Ball. (Pl. XXV, Fig. 2).

Head distinctly wider than thorax; vertex narrow, one-half longer on middle than next eye, angulate, rounding to front, front in profile convex. ♀ segment short, truncate, slightly carinate, pygofers short and stout; ♂ valve long, roundingly pointed, the lateral margins concave at base, plates together equilaterally triangular, twice the length of the valve. Milky white, finely irrorate with dark fuscous. Front densely irrorate with dark fuscuous, without distinct arcs. Venation tawny, indistinct. Length, 4 mm.

Utah, Mexico.

Phlepsius arizonus, n. sp. (Plate XXV, Fig. 3).

Similar to *utahnus*, slightly larger; vertex shorter, more completely covered with dark spots; head distinctly wider than pronotum, sub-angulate; vertex wider than long, one-third longer at middle than at eye. Pronotum one-half longer than vertex, hind border nearly straight. ♀ segment short, scarcely longer than preceding; hind border faintly sinuate. A deep slit at middle reaching nearly to base. Gray; vertex pronotum and face densely irrorate with blackish; elytra closely inscribed with blackish ramose lines; legs annulate and spotted with black. Length, 4.25 mm.

Described from one specimen, (type), Osborn collection, Tempe, Arizona, 9, 26, '17, collected by H. L. Dozier.

Phlepsius pulchripennis Baker. (Fig. 1).

Head wider than pronotum; vertex angulate, one-third longer on middle than at eyes, rounding to the front; front convex in profile. ♀ segment, nearly twice as long as preceding, truncate; ♂ valve

triangular rounded behind; plates short, triangular, margins slightly concave. Gray and milky white, with fuscous and black lineations and spots. A black spot on clavus and four conspicuous black spots on costa. Length, ♀, 4.75–5 mm.; ♂, 4–4.25 mm.

Southern States.

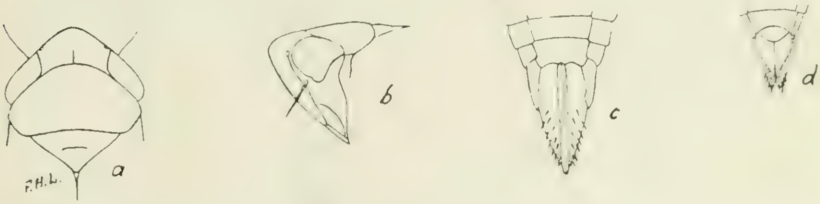


Fig. 1. Phlepsius pulchripennis Baker.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius floridanus Ball. (Pl. XXV, Fig. 4).

Resembling *irroratus* but smaller, form of *pulchripennis*, but with a longer vertex and about seven spots on the costa. ♀ segment rather long, rounding posteriorly with a pair of small rounding lobes on the median fourth.

What appears to be a male of this species has a broad, large valve nearly equalling the preceding segment in length; plates triangular, outer margins nearly straight, apices acute, about two and one-half times as long as valve. Length, ♀, 5 mm.; ♂, 4.5 mm.

Florida, South Carolina, North Carolina, Alabama.

Phlepsius graniticus n. sp. (Pl. XXV, Fig. 5).

Resembles *P. floridana* in size and shape, but has very distinct pigment lines; genital plates shorter. Head wider than pronotum. Vertex convex, subangulate, slightly longer on middle than next the eye, anterior edge obtuse. Front broad at base; ocellus close to the eye. Clypeus long, widening slightly to apex, loræ elongate. Cheeks sinuate below the eye, narrowed toward clypeus. Pronotum strongly arcuate in front, distinctly sinuate behind, lateral margins very short. ♂ valve broad and short, scarcely angulate behind; plates short, narrowing very abruptly from the bases, which scarcely reach the side margins of the valve, borders scarcely sinuate, black margined, lined with fine cilia. Dark gray, whitish, with deep fuscous dots and pigment lines. Vertex with two transverse fuscous spots between the eyes; front fuscous with minute dots and traces of arcs whitish. Elytra milky white, the veins and pigment lines blackish, a series of about 8 larger spots on costa. Length, ♂, 4 mm.

One specimen, Fryeburg, Me., collected by C. P. Alexander. This species cannot be associated with any other known form, although it has evident affinities with *P. floridana*. Type, Osborn collection.

Phlepsius costomaculatus Van D. (Pl. XXV, Fig. 6).

Head wider than pronotum; vertex roundingly subangulate, slightly longer on middle than against eyes, broadly rounding to front. ♀ segment about twice as long as preceding, nearly truncate. ♂ valve rather long, rounded; plates short, triangular outer margins straight, apex acute. Light gray with a distinct spot on the clavus, four black spots on the costa, pattern on elytra like *pulchripennis* but lighter. Length, 4 mm.

Texas, Mexico.

Phlepsius attractus Ball. (Pl. XXV, Fig. 7).

"Resembling *floridanus*, but with an evenly rounding vertex and a smaller number of spots on the costa." ♀ segment half longer than preceding, with border bisinuate. ♂ valve broad and short, bluntly rounding; plates small, margins slightly concave, their rounding apices upturned, about three times the length of the valve. Disc of the plates ivory white, polished. Length, ♀, 5 mm.; ♂, 4.25 mm.

Florida.

Phlepsius loculatus Ball. (Pl. XXV, Fig. 8).

Small; head wider than pronotum; vertex narrow, slightly longer than basal width, as long as pronotum, obtusely angled; apex bluntly rounded; front long, narrow; elytra long, narrow; venation as in costomaculatus. ♀ segment short, hind margin slightly notched at middle; pygofers long. ♂ valve triangular; plates together equilaterally triangular. Dark brown or black and white, ashy appearance; vertex white, sometimes suffused with yellow, with two pairs of brown dots on front margin near apex. Pronotum milky, with four broad mottled dark brown stripes; elytra milky with black markings similar to *costomaculatus*. Length, 3 to 3.5 mm.

Utah and California.

Phlepsius denudatus Ball. (Pl. XXVI, Fig. 1).

Almost white, very pallid, irrorations almost obsolete. Head wider than thorax; vertex one-third longer on middle than next eye, rounding to front; front convex in profile. ♀ segment about twice as long as the penultimate, the lateral angles feebly, angularly produced, the margin between them very slightly rounding with a small semicircular median emargination. ♂ valve small, short, broad, rounded behind, plates broad, triangular, together forming a nearly equilateral triangle. Whitish with obscure irrorations, vertex with broken black spots near anterior border, black behind eyes on pronotum, triangular black spots on basal angles of scutellum and a smaller pair on the disc; front with faint brownish arcs. Length, 4.5 mm.

S. W. New Mexico, Arizona, S. California.

Phlepsius stellaris Ball. (Pl. XXVI, Fig. 2).

Similar to *loculatus* in structure, and *denudatus* in color. Head broad; vertex short, obtusely rounded; scarcely longer at middle than next the eye; front short; elytra long, narrow; venation obscure. ♀ segment broad, short, almost parallel with margin, with a slight median notch. Creamy white; ocelli and four equidistant dots on vertex margins between these dark, a pair of irregular star-shaped spots on anterior disk of vertex; one ray of each star including the outer margin spot on either side, and another touching the eye; elytra creamy; nervures faintly fulvous; face and below creamy; with brown arcs on either side of the front between the antennal sockets, attached to a brown cloud in center forming a spider like marking on face. Length, 4 mm.

St. George, Utah.

Sub genus PHLEPSIUS Fieb.

Phlepsius latifrons Van D. (Pl. XXVI, Fig. 3).

Head wider than pronotum, vertex short, evenly rounding, scarcely longer on middle than against eye, front in profile convex. ♀ segment very long, deeply notched on middle, lateral lobes slightly reflexed, tips edged with black. Dark gray, coarsely irrorate with dark fuscous; vertex creamy with dark brown irrorations arranged in clouds on each side of middle; front mottled with whitish, with about four indistinct arcs on each side. Length, 7 mm.

Tennessee, North Carolina, Georgia, Florida.

Phlepsius maculosus Osborn. (Pl. XXIII, Fig. 1).

Phlepsius maculatus Osb. (Pre-occupied), Ohio Nat., Vol. V, p. 276, 1905.

Large, coarsely maculate; head equalling pronotum in width, vertex short, scarcely longer on middle than next eye, rounding to front; slightly more acute at apex, front in profile distinctly convex. ♀ segment two and one-half times as long as preceding, narrowing to hind border, produced medially with a central black disc, polished black either side the median line. Milky white with dark irrorations blending into maculations on head, pronotum and elytra. Four dark spots on anterior margin of vertex, two rounded blackish spots, including whitish pupil, next hind border. Length, 7 mm.

One specimen from Sandusky, Ohio, (Type in Osborn Coll.) Also taken in New York (Olsen).

Phlepsius pusillus Baker. (Pl. XXVI, Fig. 4).

Head broad, wider than thorax; vertex broad, slightly longer on middle than against eye, evenly rounding, rounding to front; front in profile convex. ♀ segment twice as long as preceding, posterior angle lobate, median part truncate or slightly produced, a distinct median carina, on each side of which is a dark point. ♂ valve short, angulate behind, plates about 3 times as long as valve, narrowing to behind

center, extending into acute points. Brown with fine irrorations; vertex with two white spots near hind border, ocelli margined with white, front with fragments of a few arcs, elytra with milk-white patches. Length, 4.75 mm.

Described from Maryland. Redescribed from specimen from Washington, D. C.

Phlepsius fuscipennus Van D. (Fig. 2).

Head slightly wider than pronotum, scarcely angulate, short; vertex slightly longer at middle than next the eye; front broad. Pronotum short, slightly concave behind; elytra narrow and flaring toward tip. ♀ segment one-half longer than preceding; hind border bisinuate, a rather broad lobe at center margined with black. ♂ valve long, angulate, rounded at tip; plates broad at base, sides concave, tip acute. Dark brown to fuscous, uniform above, closely irrorate; elytra sometimes with darker spots. Length, ♀ 6 mm.; ♂ 5.25 mm.

Eastern United States, New York to Florida; west to Illinois, Kansas and Louisiana.

Fig. 2. Phlepsius fuscipennis VanD.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius tigrinus Ball. (Pl. XXVI, Fig. 5).

Head wider than pronotum; vertex short, scarcely longer on middle than next eyes; sloping, rounded at front. Front in profile convex, broad at base, narrowing to clypeus. ♀ segment twice as long as preceding, posterior margin slightly emarginate, middle third weakly produced and dark margined. ♂ valve triangular, plates narrowing to rounded tips. Tawny brown, reticulations faint; scutellum light yellow, basal angles tawny; front with arcs very faintly indicated. Length, 6 mm.

Cantwell Cliff, Ohio. In Pine Association. Described from Washington, D. C.

Phlepsius turpiculus Ball. (Pl. XXVI, Fig. 6).

Head as wide as pronotum, vertex but little longer at middle than next the eye, margin roundingly angulate, front broad above, subangulate at antennæ, narrowing sharply to clypeus, which is narrowed

near its base. ♀ segment twice as long as penultimate, with a slight notch at middle, sinuated each side, lateral angles rectangular. ♂ valve triangular, margins indented midway to apex; plates narrowed to near middle then tapering to acute tips, similar to *irroratus*. Dull creamy white, rather minutely irrorate with brownish or fulvous, a lighter tip and crescent on the vertex and faint arcs on the front. Length, ♀ 7 mm.; ♂ 6 mm.

Originally described from Holly and Ft. Collins, Colo., and Stratton, Neb., and with later records from Ontario and New York. We have specimens referred to this species which extend its range to Hodgman Co., Kans. (Lawson), Olivia and Brownsville, Tex., (H. O.), Shreveport, La., (Mally), Langdon, Mo., Chicago, Ill. (J. G. S.), Union Pt., Ga., and Columbia Orangeburg, Yemassee and Charleston, S. C. (F. H. L.), Bay Pt., Marblehead, Ohio (H. O.).

Phlepsius micronotatus n. sp. (Pl. XXIII, Fig. 3).

Somewhat like turpiculus but with the elytral reticular pigmentation in minute dots; a double black spot on base of front, barely showing above. Head slightly broader than thorax, broadly rounded, scarcely angulate. Vertex scarcely longer on middle than next the eye, margin obtuse; front broad, narrowing uniformly from antennæ to clypeus; loræ broad; cheeks sinuate below the eye. Pronotum short, nearly semicircularly arched in front; posterior border distinctly concave. Elytral venation rather faint, mostly obscured by the minute pigment granules. ♀ segment about twice as long as preceding, posterior border sinuate, median third slightly produced, notched on middle with a bifid black spot, lateral angles distinct. ♂ valve short, broad, obtusely angulate behind; plates narrowing uniformly to rather blunt divergent tips, lateral margins slightly concave, set with six short spines on dark dots. Gray, faintly suffused with tawny or yellowish. Vertex light yellowish minutely dotted with fuscous. Pronotum and scutellum minutely irrorate. Elytra dull whitish, densely covered with minute dots, leaving occasional open spaces. Front whitish, minutely dotted with fuscous, arcs faintly indicated. Length, ♀ 7 mm.; ♂ 6.5 mm.

Described from three females and four males. Guadalajara, Mexico, Aug. 12, 1903. Type and paratypes, Osborn Coll.

Phlepsius collitus Ball. (Fig. 3).

Head as wide as pronotum, vertex scarcely longer at middle than next the eye, anterior edge angled. ♀ segment twice as long as penultimate, faintly notched at middle, either side of which there is a distinct sinus, the borders of which are blackened. ♂ valve broadly triangular, plates broad, short, margins scarcely sinuate. Vertex, pronotum and scutellum ivory white, contrasting with the darker elytra which are

densely reticulate with fuscous, and with obscure whitish bands at middle and end of clavus. Face fuscous mottled with whitish and with pale arcs on the front. Length, ♀ 6 mm.; ♂ 5.75 mm.

From Maine to Florida and west to Iowa. In meadows. A pale variety has been taken at Buckeye Lake, Ohio.

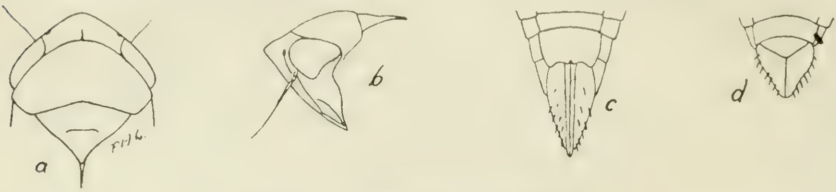


Fig. 3. Phlepsius collitus Ball.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius vanduzei Ball. (Pl. XXVII, Fig. 1).

A large species of the form of *cinereus*, gray cinereus with a trilobate commisural line; vertex bluntly conical, one-fourth longer at middle than at eye, rounded to front; front short; clypeus long, wedge-shaped, broadest at apex; elytra broad, flaring at apex. ♀ segment interrupted, appearing as a narrow strip either side, within which is a thin membrane shaped much as apertus. ♂, valve triangular; apex obtusely angular; plates broad at base, roundingly triangular; apices depressed and slightly divergent. Dull whitish, sometimes washed with yellow on vertex and pronotum; vertex with a round black spot either side at base. Pronotum and scutellum faintly marked; elytral veins yellow and fuscous; areoles finely, sparsely marked with ramose lines. Length, 8 mm.; width, 2.75 mm.

Described from Rifle, Colo. Type in Ball Collection.

Phlepsius nigrifrons Ball. (Pl. XXVII, Fig. 2).

Head wider than pronotum; vertex short, slightly longer at middle than next the eye; front full, broad at base; elytra broad, compressed behind, resembling *vanduzei*, but with apical cells short. ♀ segment wanting or appearing as a pair of widely separated rectangular plates, a pair of roundingly pointed plates overlap these on their inner margins, leaving the median fourth exposed. Male valve rounding, with the apex bluntly produced; plates together nearly semicircular, with the apices bent up and slightly produced. Vertex pale yellow in female, a pair of brown spots at base and a small pair just back of apex, black. The black of front is visible from above, either side of apex. In the male an arch of irregular dots connect the basal spots. Two or three dots inside ocelli and the frontal markings extend up to the apical spot; front black at base with faint light arcs. Pronotum, scutellum and elytra pale with fuscous irrorations and lines; an interrupted black stripe from base beneath claval suture to first cross-nervure then becoming indistinct. Length, 7 mm.

Arkansas. Known only from type specimen in Ball collection.

Phlepsius pallidus Van Duzee.

Similar to *cinereus;* larger. Head a little wider than pronotum; vertex short, rounded to front. Pronotum nearly flat, nearly two and one-half times as long as vertex. ♀ segment long, obtusely sub-triangular; apex broad, emarginate, sides interrupted by small lobate lateral angles. Pale cinereus, tinged with fulvous beneath and on disk of pronotum; pronotal irrorations irregular in front, leaving four to six white spots; elytra white with a narrow sub-basal band and about three coalescing bands beyond middle, forming an obscure w, pale fulvous. Length, 7.5 mm.

Texas.

Phlepsius cinereus Van D. (Pl. XXVI, Fig. 7).
Phlepsius optatus Crumb. Ann. Ent. Soc. Am., Vol. VIII, p. 194, (1915).

Head scarcely wider than pronotum, vertex rounding scarcely angulate, scarcely longer on middle than next eye, margin obtusely angulate front convex. ♀ segment twice length of preceding, ridged and elevated, posterior margin nearly truncate, lateral angles rectangular, two black points either side of a median notch. ♂ valve short, broadly rounded, plates narrow, bases scarcely broader than valve, tapering to bluntly rounded tips, exceeding pygofer. Light gray. Milky whitish with fuscous irrorations and lines and a distinct blackish spot at end of claval vein. Length, ♀, 6 mm.; ♂, 5 mm.

Described from Texas and now known from Iowa, Kansas, Florida, Mississippi, Louisiana, Ohio, North Carolina.

Optatus Crumb seems to merge into *cinereus* when any large number of specimens are compared and we have concluded that it must be placed as a synonym.

Phlepsius cottoni, Sanders & DeLong, (Pl. XXVII, Fig. 3).
Proc. Ent. Soc. Wash., Vol. XXIV, p. 98, 1922.

Head blunt, short; vertex margins nearly parallel, a trifle longer on middle than next the eye. Pronotum more than twice as long as vertex; elytra broad, tips flaring. ♀ segment "twice as long as preceding. Side margins abruptly narrowed about one-third the distance to apex, then convexly produced to posterior margin, which is slightly sinuated forming four indistinct lobes, a small one at either side and two larger ones at middle, the latter two separated by a rather broad, shallow notch." ♂ valve triangular, almost equilateral, longer than last ventral segment; plates divergent, produced the length of valve beyond its apex, outer margins at base almost straight then abruptly narrowed at two-thirds their length to the robust, parallel margined and bluntly rounded apices. Vertex, pronotum, scutellum and face white, rather heavily but irregularly irrorate with brown. Scutellum more heavily marked, with three conspicuous white spots, one at apex and one midway

on either side. Elytra white, rather sparsely and irregularly inscribed with brown. Posterior half more heavily inscribed, apex and spots along costa dark brown.

Described from Florida. Specimens from Raleigh, N. C. July, 1919, (Osborn and Metcalf).

Phlepsius lascivius Ball. (Pl. XXVII, Fig. 4).

Head scarcely wider than pronotum, vertex slightly longer on middle than next to eye, rounding to front; front in profile convex. ♀ segment very long, hind margin truncate, middle third slightly produced, with a median notch. ♂ valve broad, obtusely angulate behind; plates broad to base, narrowing rather uniformly, distinctly divergent. Yellowish white with brownish fuscous irrorations, vertex white at tip with polished black spot on each side, a few indistinct arcs on front. Length, 6 mm.

Holly, Pueblo, Ft. Collins, Colorado; Kimball, Nebraska, (Ball); also Devil's Lake, N. D. (H. O.); Kalispell, Mont. (H. O.); Lewis Springs, Arizona, (H. M.).

Phlepsius collinus n. sp. (Pl. XXVII, Fig. 6).

A small, dark, rather broad species, with head broader than pronotum, and general appearance somewhat similar to *altus*, but with distinct genitalia. Head slightly wider than pronotum, distinctly angulate. Vertex rather narrow, about twice as wide as long, nearly half longer on middle than against eye, distinctly angled to front; front broad and short, narrowed abruptly from antennal sockets to clypeus; clypeus long, over twice its basal width; lora large, nearly half the width of the cheek; margin of cheek sinuate. Pronotum short, more than twice wider than long, broadly arcuate in front, nearly twice length of vertex, scarcely concave behind, lateral margins short, carina very short but distinct. Claval veins approaching each other near the middle. Elytra but little exceeding the abdomen. ♀ segment twice as long as penultimate; hind border slightly produced, notched on middle; lateral lobes rounded, median apical third polished black. ♂ valve broad, obtusely angulate behind; plates short, abruptly narrowed to the rounded, closely attigent tips. Apical part of valve and median part of plates lighter, margin dusky, with a few short, whitish hairs. Dark gray to fuscous. Vertex, pronotum and scutellum dark fuscous, faintly irrorate with whitish dots. Elytra milky white with dark brown veins and blackish lines and dots. Face dark fuscous minutely dotted with yellowish. Abdomen beneath dark fuscous. The whole insect with a faint metallic lustre. Length, ♀, 5 mm.; ♂, 4.5 mm.

Anacostia D. C. (J. G. Sanders). Type, (Osborn collection.)

Also collected in grass in a wash or gully, on a hillside, at State Experiment Farm, Swannanoa, N. C., August 22, 1919.

Phlepsius altus O. & B. (Pl. XXVII, Fig. 5).

Small, ovate, head slightly wider than pronotum, vertex short, about one-fifth longer on middle than next eye, bluntly angulate to front; front in profile convex. ♀ segment with the lateral angles extended into blunt lobes; between these the margin is transverse and black marked. ♂ valve rather large, triangular, plates short, about twice as long as valve, narrowing uniformly to subacute tip. Grayish white, minutely and rather regularly irrorate with fuscous dots and lines, ocelli circled with whitish; front with faint indications of arcs. Length, 5 mm.

Western prairies and plains, on grass. Also recorded for New Jersey, Maryland, Florida (V. D.) but these records may include *collinus*.

Phlepsius incisus Van D. (Pl. XXVIII, Fig. 1).

Head scarcely wider than pronotum; vertex short, angulate, slightly longer on middle than against eye, distinctly angled with front, front convex in profile. ♀ segment elongate, narrowed behind, notched on middle, outer border of lateral lobes edged with black. ♂ valve broad, obtusely angulate behind; plates two and one-half times as long as valve, margin sinuate, apex roundingly acute. Grayish, irrorate with tawny and fuscous; vertex with broken ivory white line on anterior margin, front with three or four arcs and a few distinct light points near the base. Length, 6 mm.

Massachusetts, Ohio, New York, Pennsylvania, Michigan, Tennessee.

Phlepsius tubus Ball. (Pl. XXVIII, Fig. 2).

Similar to *fuscipennis*. Head wider than pronotum; vertex narrow, rounded to front, slightly produced at tip; front broad, short, elytra broad, slightly flaring. ♀ segment broad, short, hind margin with four rounded lobes, the middle pair slightly broader than the lateral ones, black margined. ♂ valve long, triangular; plates short, rugose at base, bluntly spoon-shaped at tip. Vertex, pronotum and scutellum fulvous-brown, irrorate with yellowish; elytra finely reticulate with ivory-white; veins tawny. Length, 5.25 to 5.75 mm.

District Columbia, North Carolina and Alabama.

Phlepsius irroratus Say. (Fig. 4).

Head slightly wider than pronotum; vertex obtusely angulate, about one-fourth longer at middle than next the eye; margin nearly right-angled with front. Elytra long, narrowed toward tip. ♀ segment deeply notched each side of an acute central tooth, lateral lobes rectangular, their inner part blackish, a median carina and a faint carina on each side extending to the tip of the lateral lobes. ♂ large, broad;

plates abruptly narrowed to before the middle, then narrow strap-like, bluntly pointed and reaching tip of pygofer. Dull yellowish with fuscous irrorations on head and pronotum and ramose lines on elytra. Length, ♀, 6 mm.; ♂, 5.5 mm.

Widely distributed from Atlantic to Pacific and Canada to gulf. Especially common in meadows and pastures and of economic importance. (See Osborn Bull. 108, Bur. Ent., U. S. Dept. Ag.).

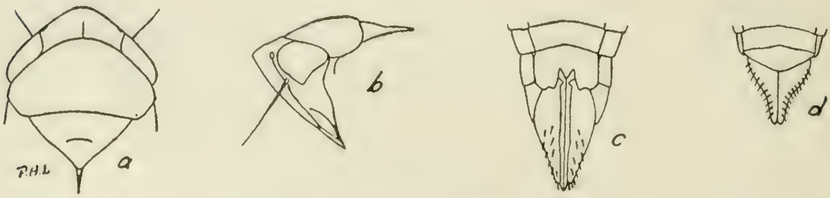


Fig. 4. Phlepsius irroratus Say.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius truncatus Van Duzee. (Pl. XXVIII, Fig. 3).

Resembles *irroratus* but with entirely different genitalia. Head slightly wider than pronotum, vertex obtusely angulate, about one-fourth longer at middle than next the eye. ♀ segment twice as long as penultimate, raised on the disk, central part truncate at tip, the lateral portions slightly convex, rounded at the angles. ♂ valve broad, short, scarcely angulate; plates elongate triangular, acute at tip. Dark gray, fuscous irrorations and pigment lines on whitish ground. Length, ♀, 5.5 mm.; ♂, 5.25 mm.

Pennsylvania to Florida and west to Iowa.

Phlepsius lobatus Osborn. (Pl. XXIV, Fig. 1).

Head slightly wider than pronotum; vertex subangulate, slightly longer at middle than next the eye. ♀ segment rounded at middle with a median and lateral carina, lateral angles produced into prominent lobes. ♂ valve short, rounded behind; plates short, broad at base, narrowing abruptly to blunt tips. Vertex dirty yellowish, with fine irrorations. Front minutely irrorate, with a pair of oblique spots and four arcs. Elytra whitish with brown and fuscous dots and lines. Length, ♀, 5 to 5.25 mm.; ♂, 4.5 mm.

Iowa, Wisconsin, Kansas.

Phlepsius maculellus Osborn. (Pl. XXVIII, Fig. 4).

Head wider than pronotum, subangulate, vertex about one-fourth longer on middle than next eye, rounding to front; front in profile convex. ♀ segment long, about twice length of preceding, lateral angles produced in short rather acute lobes, hind border nearly straight

elevated, notched at middle, broadly bordered with black. ♂ valve triangular, obtusely angled behind, plates short, broad at base, narrowing abruptly to obtuse tips, about one and one-half times as long as valve. Ochraceous; elytra coarsely maculate with blackish irrorations, leaving quite distinct areas of milky white, vertex with two rather distinct roundish spots near hind border, front coarsely irrorate, without distinct arcs. Length, ♀, 6 mm; ♂, 5.5 mm.

One specimen Orono, Maine, August 5th, (Type, Osborn Col.), one Cranberry Lake, N. Y., (C. J. D.) Aug. 10, 1917, and both sexes Cranberry Lake, Aug. 11–12, 1920. (Osborn and Drake).

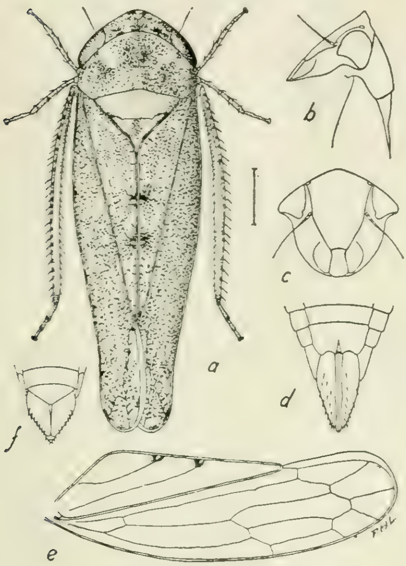


Fig. 5. Phlepsius tenessa DeLong. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron; *f*, ♂.

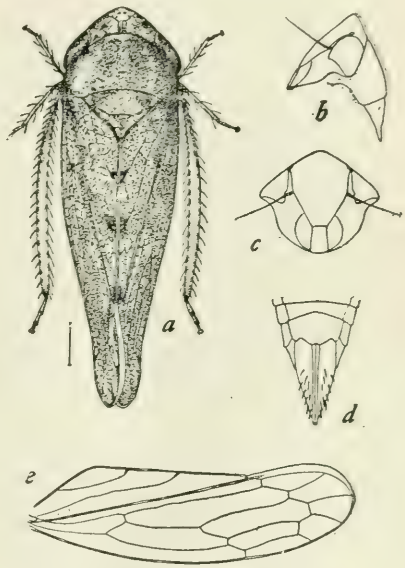


Fig. 6. Phlepsius torridus Lathrop. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron.

Phlepsius tenessa DeLong. (Fig. 5).

Head scarcely wider than pronotum, vertex angulate, one-half longer at middle than next eye, margin more acute at apex than next the eye. ♀ segment about twice the length of the penultimate, hind margin sinuate, notched at middle, lateral lobes slightly produced and rounded, black margin on median portion and a black line extending nearly half way to the base. ♂ valve large, broad, roundingly angulate, plates short, broad, narrowing to slightly produced rounded apices, numerous submarginal bristles, a light patch on disk and light border at apex. Dark gray, head, pronotum and scutellum yellowish white, closely inscribed or irrorate with fuscous; elytra milky white with

fuscous dots and pigment lines, with five more distinct spots on apical half of elytra; face dark with dense fuscous irrorations on a yellowish ground and four or five irregular frontal arcs. Length, ♀, 7 mm.; ♂ 6.5 mm.

Described from Tennessee, recorded for South Carolina, and specimens at hand from southern Ohio, Washington, D. C., Raleigh, N. C., South Carolina and Texas.

Phlepsius torridus Lathrop. (Fig. 6).

Head slightly wider than pronotum, vertex broadly angular, one-half longer at middle than next the eye, anterior edge bluntly angular. ♀ segment twice as long as preceding, median part slightly notched at middle, lateral angles obtuse. Golden brown, nearly uniform above, front dark with a few arcs, clypeus and loræ lighter, a light spot on the cheek just above the upper angle of the lora. Length, ♀, 6 mm.

Described from South Carolina. A specimen taken at Swannanoa, N. C., slightly larger agrees very perfectly with the type except that the ultimate ventral segment of the female is more depressed at the sides of the median lobe.

Phlepsius rileyi Baker. (Pl. XXVIII, Fig. 5).

Head scarcely wider than pronotum, vertex rather narrow, one-half longer on middle than against eye, distinctly angulate, bluntly angled with front, front in profile slightly concave near margin, below straight to clypeus. ♂ valve rather long, distinctly angulate behind, plates elongate, nearly twice length of valve, tips rather acute. Tawny, elytra irrorate with fuscous, vertex with two transverse bars; front brown, with indistinct whitish arcs and central line and spots near base. Length, 8 mm.

Texas.

Phlepsius brunneus DeLong. (Pl. XXVIII, Fig. 6).

Head scarcely wider than pronotum. Vertex flattened, distinctly but obtusely angled, half longer on middle than next the eye, margin acute at tip, rounding toward the eye. ♀ segment twice length of preceding, median part slightly produced, elevated, black margined, lateral lobes rounded. ♂ valve large, slightly longer than preceding segment, obtusely angled; plates broad at base, rather short, tips rounded. Brown with yellowish or whitish dots and irrorations. Front fuscous at base, brownish at tip, two dots below the margin, four or five irregular arcs. A large light spot on disc of the lora. Length, ♀, 7 to 7.5 mm.; ♂, 6 to 6.5 mm.

Tennessee (DeLong). East Sister Id., Lake Erie (H. O.).

Phlepsius texanus Baker. (Pl. XXIX, Fig. 1).

Head wider than pronotum; vertex short, obtusely angulate, slightly longer at middle than next the eye; front broad at base, tapering nearly uniformly to clypeus; pronotum more than twice as long as vertex, faintly concave behind; elytra broad, long, slightly flaring at tip. ♀ last ventral segment half longer than preceding; lateral angles slightly produced into short lobes, between which the border is nearly straight, margined with fuscous. ♂ valve short, obtusely angled; plates short, broad at base, tips broadly rounded. Dark gray, irrorate with fuscous; claval veins tipped with white; elytra clouded with fuscous patches, composed of fine lines and dots; legs banded with fuscous. Length, 6.5 mm to 7 mm.

Texas.

Phlepsius apertus VanDuzee. (Pl. XXIX, Fig. 2).

Head slightly wider than pronotum, vertex roundingly angulate, about one-third longer at middle than next eye, anterior edge bluntly angled. ♀ segment with a broad excavation, the middle third reaching to near base, lateral lobes quadrangular with the inner margin blackened. ♂ valve large, broad subangulate, plates broad at base, narrowing sharply to about the middle then extending as narrow bluntly tipped upturned processes exceeding the pygofer, much like *irroratus*. Dark gray, fuscous irrorations on whitish ground, an obscure whitish band crossing before the middle of the clavus and a whitish area at tip of clavus. Length, ♀, 6 mm.; ♂, 5 mm.

Northern U. S., extending from Maine to Rocky Mountains.

Phlepsius apertinus n. sp. (Pl. XXIX, Fig. 3).

Head slightly wider than pronotum, distinctly angulate, vertex about one-third longer at middle than next eye, acutely angled with front on apical third, one-half longer on middle than next the eye; front broad, sides parallel to antennæ, then narrowing sharply to clypeus; clypeus narrow, slightly wider at apex than at base, loræ broad, nearly reaching border of cheeks; pronotum strongly arched in front, shallowly concave behind; elytra slightly flaring. ♀ segment excavated on median third to base as in *apertus*, lateral lobes converging but not meeting at apex. ♂ valve much as in *apertus*, broad, obtusely angled behind; plates broad at base, narrowing to beyond the middle, terminating in blunt strap-like lobes; plates are longer and more nearly parallel than in *apertus*. Dark brown or blackish, vertex, pronotum and scutellum whitish with irrorations varying from dark fulvous to blackish; elytra with heavy dark fuscous or blackish pigment lines, leaving a distinct irregular light band before the middle of clavus, a few large whitish spaces on apical part of clavus and elytra, a series of dark, distinct blackish spots on the costa; front distinctly black at base, becoming lighter at clypeus with about four irregular broken

arcs; clypeus yellowish, a central dark line at apex; loræ irrorate with a lighter patch on outer border; legs annulate with fuscous. Length, ♀, 6.5 mm.; ♂, 6 mm.

This species is very much like *apertus* in the genitalia but the excavation on the female segment is wide at base and converging at tip and the male plates longer while the vertex is longer and more acute at tip and the narrow whitish band on the elytra presents a different picture.

Described from specimens collected at Corvallis, Oregon, by the junior author and Van Duzee and Thompson in California. Type and paratypes, in collections of the authors and Cal. Acad. Sci.

Phlepsius carolinus Lathrop. (Pl. XXII, Fig. 1).

Head wider than pronotum; vertex long, subangulate, one-third longer on middle than next eye, angulate with front; front in profile convex. ♀ segment twice as long as preceding, central area elevated and flat, laterally fluted, hind margin deeply sinuate on fluted portion. ♂ valve wide, short, rounding behind, plates narrowing uniformly to blunt tips, nearly three times as long as valve. Ashy gray, with slender irrorations and reticulations; vertex with dark spot near apex with slender light median line, expanding on tips, front brown with minute yellow dots, two light areas on each side of disc; no distinct arcs.

Specimens from South Carolina (Lathrop), Tennessee (DeLong).

Phlepsius particolor, Sanders & DeLong, (Pl. XXIX, Fig. 4).
Penna. Department of Ag., Vol. III, p. 15.

Head short, slightly produced; vertex one-half longer at middle than next to eye; margin bluntly angled at side, sharp at tip. Pronotum strongly arched, concave behind; elytra broad, tips flaring. ♀ segment produced, triangular, twice as long as preceding segment; apex with a broad incision narrowed at half its depth, and extending one-third its distance to base; margin and incision bordered with black. Vertex, pronotum and scutellum yellowish, slightly mottled with brown; elytra whitish, inscribed with dark brown; two white spots at tip of claval veins; costa with small irregular brown spots; face finely irrorate with brown. Length, ♀, 7 mm.

Kane, Pa.

Phlepsius fulvidorsum Fitch. (Pl. XXIX, Fig. 5).

Head scarcely wider than pronotum, vertex one-half longer at middle than next eye, angulate, margin acute at apex, more obtuse at eye. ♀ segment nearly twice as long as penultimate, posterior border slightly produced, raised on middle, lateral lobes prominent and depressed.

♂ valve rather large, obtusely triangular, plates broad at base, narrowing rather uniformly to acute, upturned apex. Vertex, pronotum and scutellum light fulvous, contrasting distinctly with the darker elytra. Elytra milky white with pigment lines and dots of fuscous and brown; face fuscous, minutely dotted with yellowish, frontal arcs distinct. Length, ♀, 6 mm.; ♂, 5.75 mm.

North-east U. S. west to Rocky Mountains, south to North Carolina. On grass in pine woods.

Phlepsius eburneolus n. sp. (Pl. XXIV, Fig. 3).

Similar to *fulvidorsum* but the ivory like anterior part of body contrasts still more sharply with the dark elytra and the female genital segment is quite different.

Head broader than pronotum, vertex obtusely angular, one-third longer at middle than next the eye, apex at center sharp-edged, ocelli close to eyes; front broad at base, tapering sharply to apex; clypeus narrow, nearly twice as long as wide, truncate at apex; loræ longer than broad, reaching nearly to margin of cheek; genæ slightly angled. Pronotum strongly curved in front, deeply sinuate behind; scutellum large; elytra densely marked with ramose lines. ♀ segment over twice as long as penultimate, narrowed and truncate behind, with a small central notch. ♂ valve triangular; plates elongate triangular, acute at tip. Vertex, pronotum and scutellum light ivory yellowish white with faint fulvous irrorations on the anterior margin of vertex, a faint broad fulvous stripe in the center of scutellum and the basal angles faintly fulvous. There are two blackish spots on the margin of scutellum each side and the elytral ramose lines are dark brown to fuscous, giving a chocolate tinge, although the interstices and cells are milky white. Fairly distinct spots of blackish occur on the elytra beyond the tip of clavus and along costal apical border and the legs are banded with blackish. Length, ♀, 5.25 mm.

Described from one specimen female, (type) in Osborn collection, labeled "Vinita, Ind. Ter. June 8, 1899" and collected by H. F. Wickham. A female (paratype) and ♂ (allotype) from Ashburn, Va., collected by L. A. Stearns. The first specimen has been in hand for many years and the description deferred in hopes that additional material and especially the male might be secured but this hope was not realized until the species was collected in Virginia by Mr. L. A. Stearns.

Phlepsius tullahomi DeLong. (Pl. XXIX, Fig. 6).

Head wider than pronotum, obtusely angulate; vertex one-fourth longer at middle than next the eye, somewhat depressed; margin acute at middle; front broad, narrowing nearly uniformly to clypeus; clypeus long, widening toward tip; loræ large, nearly reaching border of cheek; cheek margins rounded, gently sinuate. Pronotum about three times as long as vertex; hind border distinctly concave. ♀ segment one-half

longer than preceding, hind border sinuate at sides, with median produced tooth, notched at the middle. ♂ valve large, angled behind; plates broad at base, nearly triangular, tips acute. Length, ♀, 6 mm.; ♂, 5.25 mm.

Described from Tennessee, and specimens are in hand from Cantwell Cliff, Ohio, Aug. 4, 1921, (Osborn); Auburn, Alabama, May 23, 1922, "at light," (F. E. Guyton), and Pennsylvania, (De Long).

Phlepsius slossoni Ball. (Pl. XXII, Fig. 3).

Phlepsius franconianus Lathrop, Bull. 199, S. C. Ex. Sta., p. 93.

Head slightly wider than pronotum, broadly angular; vertex one-half longer on middle than next the eye. Anterior edge acute, sharpest at apex. Front slightly concave below apex of vertex. ♀ segment one-half longer than penultimate, posterior margin slightly produced and minutely notched on middle, shallowly sinuate laterally, lateral angles obtuse. Dark gray, a dull cloud on apex of vertex. Pronotum suffused with blackish on disc. Scutellum light. Elytra whitish with delicate dots and lines. Face white, minutely dotted with brown. Beneath whitish. Length, 6 mm.

Florida, South Carolina (F. H. L.), Southern Pines, N. C., (Manee).

Phlepsius fastuosus Ball. (Pl. XXX, Fig. 2).

Similar to *slossoni*, larger. Vertex short, obtusely angular; apex blunt, nearly twice longer at middle than next eye; disk flat; anterior margin thin, slightly foliaceous at apex. ♀ segment long, hind margin truncate, nearly two-thirds angularly produced, elevated, slightly notched at apex. Vertex brownish-gray, a cross on the apex; lateral margins and a few dots on the disk ivory white. Pronotum brownish-gray, irrorate with whitish; elytra milky white, with fine reticulations and small dots of brownish fuscous, mostly arranged in two bands, one rather narrow and definite across posterior third of clavus, the other broader, less distinct, occupying space behind clavus. Length, 7.5 mm.

New Mexico.

Phlepsius franconianus Ball.

Head wider than pronotum; vertex subangulate, margin thin, acute at tip, rounded near eye; front in profile concave above, convex below. ♂ valve triangular, two-thirds the length of the ultimate segment; plates long, triangular, their margins straight, apices acute, two and one-half times the length of the valve, slightly exceeded by the pygofers. Light gray; vertex and pronotum fawn color, elytra finely irrorate with brown lines and dots forming faint bands at middle of clavus at apex of clavus and before tip of elytra. Front minutely irrorate, a white mark at base, with faint indications of light arcs. Length, ♂, 5 mm.

New Hampshire.

Phlepsius lippulus Ball. (Pl. XXIX, Fig. 7).

Head wider than pronotum, vertex distinctly angulate, half to two-thirds longer on middle than against eye, flat, margin acute at tip, rounded near eye; front in profile, deeply concave above, convex below. ♀ segment long, about twice length of preceding, truncate, middle third produced into a feeble lobe. ♂ valve short; plates triangular, acute. Vertex, pronotum and scutellum gray, with whitish band back of middle of clavus, another at tip of clavus, forking midway and terminating on costa in two black spots; another band on apex blackish.

Florida, Mississippi, Texas.

Phlepsius fulviceps n. sp. (Pl. XXX, Fig. 1).

Similar to *strobi*, but with distinctly longer, angular vertex; the head fulvous; eyes red-brown; pronotum irrorate with fine yellowish dots; elytra milky white, with fulvous bands. Length, 5.25 mm.

Head scarcely wider than pronotum, distinctly angular; vertex twice as long at middle as next the eye; tip flattened; front concave below the tip, forming a flattened blunt margin; clypeus half longer than wide. Pronotum about two-thirds longer than vertex; hind border concave. ♀ segment about twice as long as preceding; hind border slightly sinuate, produced at middle into a broad obtuse tooth. Face, vertex, pronotum and scutellum pale fulvous; face with minute dots of yellowish; vertex with a faint trace of forked median line. Pronotum faintly irrorate with yellowish, transverse dots; scutellum with a yellow spot each side opposite the suture; elytra milky white with a fairly distinct fulvous band across at middle of clavus; another at tip of clavus dividing to form an arm to the costal dark spots; another near tip of apical areoles. There are numerous minute fuscous dots especially on the fulvous areas. Three dots on the costa and an apical spot at end of the apical band, fuscous. Beneath gray, minutely dotted with fuscous.

Described from one specimen, female, (type), collected at Leesville, La., April 28, 1905, by Wilmon Newell.

This species appears to be quite distinct, but has, until recently been supposed to belong to *lippulus*, Ball. It is, however, quite different from that species in the length of vertex and other characters, in some points being nearer to *strobi*, Fitch, from which it differs particularly in the length of vertex and the concave base of front.

Phlepsius uhleri Van Duzee.

Head wider than pronotum; vertex scarcely longer at middle than next the eye; front broad at base, narrowing with faint sinuation opposite eye; clypeus nearly twice as long as wide at base, widened to tip; cheeks broad, margins sinuate. ♂ valve short, obtusely angulate behind; plates triangular, outer margin slightly convex, tips acute,

scarcely acuminate, reaching tip of pygofer. Fulvous brown, minutely irrorate; elytra with indefinite lighter bands of whitish hyaline dots. 1st just back of scutellum, 2nd at tip of clavus, 3rd across base of apical areoles, middle one angled, reaching pretty closely to basal veins of anteapical areoles. Length, 4 mm.

"Odenton" Aug. 1, "Md." "Phlepsius uhleri V. Duz." Uhler's handwriting.

Phlepsius strobi Fitch. (Pl. XXX, Fig. 3).

Bythoscopus strobi Fitch, Fourth Report, N. Y. State Lab. N. H., p. 58, (1851).
Phlepsius strobi Osborn, Ohio Jour. Sci., Vol. XXIII, p. 160, 1923, (not *P. strobi* Van Duzee).

"Resembling *Phlepsius uhleri* but with longer, angular edged vertex and with three whitish bands on elytra the anterior one extending from scutellum to half way point on clavus. Head wider than pronotum, vertex angular, one-half longer at middle than next the eye, margin angular; front longer than wide, clypeus with sides nearly parallel, apex truncate loræ nearly touching margin of cheek. Pronotum twice as long as vertex, hind border slightly emarginate. ♀ segment long with median third produced. ♂ valve short rounded behind, plates triangular, tips acute. Gray fulvus. Vertex fulvus mottled with whitish and with pronotum and scutellum brown, irrorate with gray or whitish, elytra with bands of white and brown, a white band across base from middle of scutellum to middle of clavus, another just beyond apex of clavus and the third just before the apex, inscribed with delicate brown lines." Length, ♀, 4.5–5 mm. ♂ 4.1 mm.

New York and Ohio.

Phlepsius punctiscriptus VanDuzee. (Pl. XXX, Fig. 4).

Head scarcely wider than pronotum, vertex half longer at middle than next the eye. Disc depressed. Anterior edge acute at tip, rounding near the eye. ♀ segment nearly twice the length of the preceding, slightly produced at middle, apex minutely notched, lateral angles scarcely produced. ♂ valve very small, plates narrowing sharply to about one-third from base then tapering to acute tips exceeding the pygofer. Light gray to whitish; vertex tinged with fuscous, with ivory white spots on the anterior border. Head, pronotum, scutellum and elytra with minute dots; face creamy white with minute brown dots leaving a fairly distinct median line on front and traces of obscure frontal arcs. Length, ♀ 7 mm., ♂ 5 mm.

Recorded from Florida, Tennessee, Kansas, Texas and Nebraska. Males referred to this species from Texas and Iowa.

Phlepsius planus Sanders & DeLong. (Pl. XXX, Fig. 5).

S. & DeL., Pr. Ent. Soc. Wash., Vol. XXIV, p. 98, 1922.

Related to *P. nebulosus* but with very short vertex. Markings of elytra in distinctly parallel lines. Head wider than pronotum, vertex

depressed short, scarcely longer on middle than next eye, anterior edge acute. Front scarcely concave below apex of vertex, broad, cheeks rounded, scarcely sinuated below eye. Pronotum short, anterior margin broadly curved; lateral carinæ distinct, long, about as long as short diameter of eye; posterior margin distinctly concave. Elytra long, claval veins straight and parallel, cross vein faint or wanting. ♀ segment about twice length of penultimate. Hind margin sinuated, incised on middle, lateral lobes rounded. ♂ valve short angulate behind; plates broad at base narrowing to middle, tapering to blunt upturned tips. Ash gray with brown or fuscous markings. Vertex whitish, minute brownish irrorations. Vertex with white spots on posterior edge behind ocelli. Face minutely irrorate with white dots, frontal arcs faintly indicated. Pronotum and scutellum irrorate with brownish and white. Elytra dull milky whitish, veins brown, mostly margined with pigment dots, lines of pigment dots in discal, apical, and anteapical cells. Beneath, gray. Length, ♀, 7 mm., ♂, 6 mm.

Redescribed from one female, four males, Gainesville, Fla., collected by C. J. Drake; one specimen Orlando, Fla., (G. F. Ainslie).

Phlepsius nebulosus VanDuzee. (Pl. XXIII, Fig. 4).

Head wider than pronotum, roundingly angular, vertex slightly depressed nearly twice as long at middle as next eye, anterior edge acute, front slightly concave at base; ♀ segment three times as long as penultimate, middle half nearly truncate, elevated, ridged laterally to form depressed lateral lobes which are rounded at angles; ♂ valve large broad angulate, plates long, strap-like, evenly tapering to divergent obtusely pointed tips, pygofer broad, exposed at sides of plates and much exceeded by the long plates. Gray brown, vertex and anterior border of pronotum dull yellowish with brownish irrorations, disk of pronotum darker with light irrorations scutellum yellowish sparsely irrorate with brownish; elytra whitish, subhyaline, with brownish pigment lines and dots, front fuscous with yellowish dots and about five fairly distinct arcs. Length, ♀ 8 mm., ♂ 8 mm.

Eastern U. S. to Colorado, also reported for Manitoba.

Phlepsius solidaginis Walk. (Pl. XXX, Fig. 7)

Head wider than pronotum, broadly angulate, vertex depressed margin acute, front scarcely concave below apex of vertex; ♀ segment twice as long as preceding, elevated and distinctly produced at middle with a small median notch, lateral lobes rounding; ♂ valve long, roundingly subangulate behind, plates long, tapering to acute tips. Light tawny with light irrorations, elytral rather densely reticulate with traces of transverse bands. Length, ♀ 7 mm., ♂ 6 mm.

Eastern U. S. and Canada west to Kansas and south to Tennessee.

Phlepsius josea Ball. (Pl. XXX, Fig. 6).

Similar to *humidus*, much smaller. Vertex flat, slightly depressed posteriorly; twice as long at middle as next the eye; front margin thick but foliaceous. ♀ segment one-half longer than preceding; hind margin roundingly truncate; lateral angles rounded; ♂ valve very small, rounding, almost concealed; plates broad at base, semi-circularly rounding; thin, produced into long style-like attingent points. Pale yellowish-olive, flecked with irregular spots and blotches of blood red, giving a red appearance to the whole insect above and below. Length, 5.25 mm.

Colorado.

Phlepsius occidentalis Baker. (Pl. XXXI, Fig. 2).

Head scarcely wider than pronotum. Vertex roundingly angulate, one-half longer on middle than against the eye, depressed, margin acute. Front feebly concave below apex of vertex. ♀ segment more than twice as long as preceding, slightly produced and minutely notched at middle, lateral angles obtuse, margin blackish on each side of central notch. ♂ valve rather large, subangulate; plates short, broadly triangular, together nearly equilaterally triangular. Tips acutely converging, slightly upturned. Dark gray. Vertex and pronotum fuscous with whitish dots or irrorations. Vertex and scutellum lighter than pronotum. Elytra milky white with dense fuscous dots and pigment lines. Front fuscous with minute light dots, irregular arcs, a broad light spot on loræ, and whitish band across middle of clypeus. Male hitherto undescribed differs from female in having vertex slightly longer on middle, margin between vertex and front distinctly marked with ivory white.

Described from State of Washington. Specimens in hand from Pullman, Wash.; Corvallis, Ore.; and reported for San Diego, Cal.

Phlepsius nudus Ball. (Pl. XXXI, Fig. 1).

Similar to *ramosus* but not slender; vertex roundingly angled; disk flattened anteriorly; margin thin, produced. Pronotum short, scarcely longer than vertex; elytra broad, short. ♀ segment of female truncate behind, surface strongly convex with a sharp median carina and traces of two lateral ones. ♂ valve equilaterally triangular; apex rounded; plates narrow, long, spoon-shaped, three times the length of the valve, narrowly rounded at apex. Dull straw, slightly tawny on vertex; disk of pronotum and angles of scutellum washed with brown; disk of scutellum pale with a pair of brown points. Elytra sub-hyaline, somewhat milky; veins and ramose lines tawny-brown. Length, ♀ 6 mm.; ♂ 5 mm.

Florida.

Sub genus PARAPHLEPSIUS Baker.

Phlepsius bifidus Sanders & DeLong. (Pl. XXXI, Fig. 3).
Ann. Ent. Soc. Am., Vol. X, pp. 89, 1917.

Head slightly wider than pronotum, roundingly angular. Vertex one-third longer on middle than next eye, flattened, slightly depressed behind the margin; margin acute, sharpest at middle. Front flattened, barely concave below apex of vertex. ♀ segment long, deeply notched on middle, lateral lobes angularly rounded, blackish on apical half. ♂ valve broad, distinctly angular; plates broad at base, narrowing abruptly to rounded tip, together about equilaterally triangular. Dark gray, vertex yellowish with rather sparse irrorations, pronotum yellowish on anterior border, darker on disc, with light irrorations. Scutellum ivory whitish, with a few irrorations. Elytra milky white, with dark fuscous pigment lines, denser behind middle, leaving a suggestion of a lighter band before the middle. Face dark, base of front blackish, apical portion lighter, traces of two or three faint light arcs. Length, 7 mm.

Described from Wisconsin. Specimens in hand, collected at Cranberry Lake, by C. J. Drake and H. Osborn; Elka Park, Greene Co., N. Y. (Drake).

Phlepsius ramosus Baker. (Pl. XXXI, Fig. 4).

Head distinctly wider than pronotum, roundingly angulate, vertex distinctly depressed, margin acute, almost foliaceous, front concave below apex of vertex; pronotum distinctly carinate laterally. ♀ segment nearly three times as long as penultimate, somewhat produced and carinate on middle, lateral angles obtuse. ♂ valve broad, short, roundingly subangulate, plates broad at base, narrowed abruptly to about middle then tapering to blunt points which extend beyond pygofer. Dark brown or fuscous, vertex, pronotum and scutellum fuscous with numerous dots and irrorations; elytra milky whitish with dark fuscous lines and dots more dense behind the middle, leaving a fairly distinct band from base to middle of elytra; front fuscous with minute yellowish dots and traces of arcs. Length, ♀, 7 mm.; ♂, 7 mm.

North-east U. S. west to Ohio.

Phlepsius tenuifrons Sanders & DeLong.
Ann. Ent. Soc. Am., Vol. XII, p. 235, 1919.

Head broader than pronotum; vertex produced, upturned, nearly twice as long at middle as next the eye. Pronotum short, scarcely twice as long as vertex; elytra short, broad, flaring. ♀ segment long, three and one-half times preceding segment; lateral angles rounded; hind border sinuate, a shallow notch separating two small lobes at middle. ♂ valve long, roundingly angled behind; plates broad at base, narrowed abruptly before middle; tips long, blunt, passing the pygofer. Pale, with numerous brown irrorations; a brown line on vertex; face

uniformly irrorate, pale spot at upper end of loræ; elytra milky white, heavily marked with ramose lines; an indistinct saddle across middle, veins brown; beneath uniformly brown. Length, 7 mm.

Greensburg, Pa.

Sub genus ZIONINUS Ball.

Phlepsius extremus Ball. (Pl. XXXI, Fig. 5).

Vertex flattened; head scarcely as wide as pronotum; vertex broad, nearly twice as wide as long at middle, nearly twice as long on middle as next eye; head sub-angulate; front broad at base, narrowing uniformly to clypeus; clypeus long, broad at base; pronotum half longer than vertex; scarcely concave behind; elytra slightly longer than abdomen. ♀ last ventral segment twice as long as preceding, bisinuate on hind margin, faintly sinuate at middle. Light gray, marked with fuscous or black. Vertex mottled with blackish; front rather delicately inscribed with fine brown lines, clypeus and loræ with fine dots. Pronotum, scutellum, elytra whitish marked with black dots or lines. The ramose lines of elytra sparse. Length, ♀, 5 mm.

Described from Colorado, and recorded from California.

Specimen at hand collected by E. P. Van Duzee, Ashland, Oregon, Aug. 2, 1919. The species is characterized by the distinctly flattened vertex.

Sub genus TEXANANUS Ball.

Phlepsius eugeneus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 384, (1918).

"Nearly of the form of *excultus*, but larger, paler, and lacking the definite markings of that species. Pale grayish or slightly fulvous brown. Length 7 mm., width 3 mm. Vertex convex, one-fourth longer on middle than against eye, twice wider than long. Anterior margin bluntly rounding except at apex, front broader than in *hebraeus*, almost parallel margined until just before the apex. Pronotum but little wider than across eyes. Elytra longer than in *excultus*, flaring behind, the inner anteapical cell very long, the outer one broadest in front. ♀ segment long, angularly narrowing posteriorly, middle half roundingly emarginate clear to the base, where there is a slight median tooth. Male valve very short and obtuse; plates large, triangular, with nearly straight margins, white with black spots at the base of the short marginal hairs; the stout spines of the pygofers exceeding those of the plates. Pale yellow, two pairs of approximate dots on suture between vertex and pronotum, as in *excultus*, two indistinct brown spots at apex of vertex, and front brown with pale dots. Elytra milky, inscribed with brown, faintly washed with rufous in most specimens, the tips of the claval nervures fuscous."

Described from various points in Guerrero, also Cuernavaca, and Iguala, Mexico.

Phlepsius superbus Van D. (Fig. 7).

Head narrower than pronotum; vertex roundingly angulate, about one-third longer on middle than at eyes, rounding to front; front profile scarcely convex. ♀ segment broadly roundingly emarginate, about as long at middle as preceding segment. ♂ valve narrow, rather long, slightly angulate behind; plates short, broad, borders rounded, together semicircular. Brown with irrorations and reticulations dark fuscous or blackish; front blackish at base with brownish arcs and light mottlings. Length, 6 mm.

South Carolina, Southern Florida to California, south to Central Mexico.

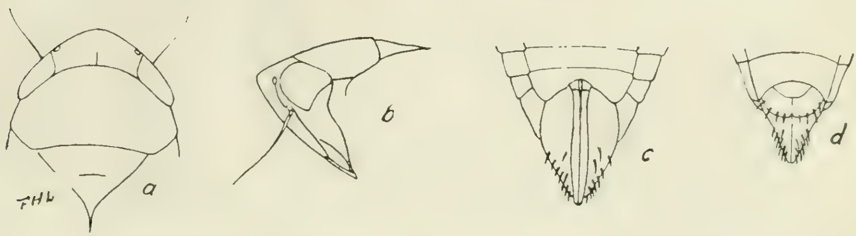


Fig. 7. Phlepsius superbus VanD. *a*, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius excultus Uhler. (Fig. 8 and Pl. XXIII, Fig. 2).

Head almost as wide as pronotum; vertex short, roundingly subangulate, about one-fourth longer on middle than next to eye, rounded to front, profile of front slightly convex. ♀ segment roundingly excavated to near the base, on median half, exposing lobes of pygofer and base of ovipositor. ♂ valve short, rounded behind, plates triangular, outer border slightly convex, tips acute. Head, scutellum and pro-

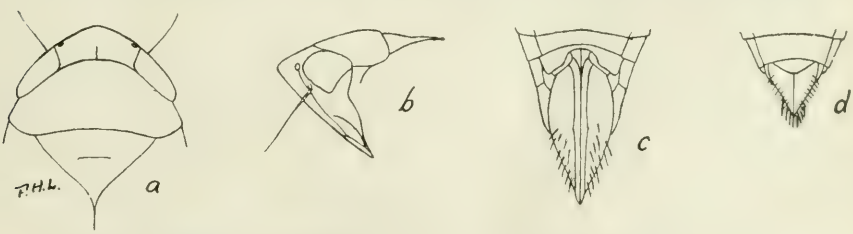


Fig. 8. Phlepsius excultus Uhler. *a*, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

notum tawny, with scattered, fuscous lines strongly contrasting with elytra; elytra ivory white, densely covered with blackish or fuscous reticulations, with lobate white spots, nerves blackish. Front mottled with light dots, not arranged in arcs. Length, ♂, 6 mm.; ♀, 6.5 mm.

Southern U. S., North Carolina, Florida, to Texas. Also "Mex." Ball. Van Duzee also notes Massachusetts, New York, New Jersey, Pennsylvania, Tennessee, Illinois, Kansas, Minnesota and Colorado.

Phlepsius rufusculus n. sp. (Pl. XXXI, Fig. 6).

Head slightly narrower than pronotum; vertex faintly subangular, about one-fourth longer on middle than next eyes, obtusely rounded to front, profile of front scarcely convex. ♀ last ventral segment nearly twice as long as preceding, faintly produced at middle with very shallow, median notch. ♂ valve narrow, subtriangular, roundingly angular behind, plates short subtriangular, finely ciliate, reaching tip of pygofers. Yellowish with reddish brown irrorations, vertex mottled with yellow and brown, anterior border ivory yellow; front with distinct brown arcs separated by median brown area, including minute yellow dots. Length, ♂, 7 mm.; ♀, 7.25 mm.

One female (type) from West St. Louis, Mo.; W. V. Warner, collector. Male (allotype), Portsmouth, Ohio, C. J. Drake, collector.

Somewhat resembles *superbus*, but differs in distribution of mottlings in front and especially in form of genitalia of both sexes. Agreement of structural and color characters makes the associations of sexes here indicated practically certain.

Phlepsius umbrosus Sanders & DeLong. (Pl. XXXII, Fig. 2).
Ann. Ent. Soc. Am., Vol. X, p. 88, 1917.

Head scarcely narrower than pronotum; vertex obtusely angled, nearly twice as long at middle as next the eye. Pronotum strongly convex, twice as long as vertex; elytra broad, broadly rounded at tips. ♀, last ventral segment twice as long as preceding; lateral angles produced, sharply rounded; hind margin convex, notched at middle, forming two produced rounded lobes, margined by a broad semi-circular brown spot extending one-half way to base. ♂ valve nearly as long as last ventral segment, slightly concave; apex obtuse; plates long, evenly narrowed to small blunt points. Dark brown; vertex evenly irrorate, a pale spot each side next to eye. Pronotum irrorate and punctulate; elytra milky white, closely and evenly inscribed with dark brown; face dark brown, evenly irrorate with testaceous. Length, ♀, 6 to 6.5 mm.

Described from Grand Rapids, Wis.

Phlepsius cumulatus Ball. (Pl. XXXII, Fig. 1).

Broadly oval, head narrower than pronotum, vertex short, scarcely longer on middle than next eyes, faintly angulate, bluntly rounded to front; front in profile scarcely convex. ♀ ventral segment longer than preceding, nearly truncate, rather broadly notched at the middle, with a shallower notch each side. ♂ valve triangular, plates twice length of valve, sides roundingly angulate, tips slightly angularly divergent. Grayish tinged with reddish, reticulations faint; vertex with faint fuscous dots forming a transverse line in front of which is

a series of faint dots; front black on base with yellow dots, arcs distinct, blending with maculations on middle. Length, 6–6.5 mm.

On plains grasses, Western plains, Kansas, Nebraska, South Dakota.

Phlepsius ovatus Van D. (Pl. XXXII, Fig. 6).

Ovate, less robust than *decorus*, head narrower than pronotum, vertex about one-third longer on middle than against eyes, rounding to front; front scarcely convex. ♀ segment slightly emarginate, notched at center. ♂ valve long, triangular, plates short, outer margin curved, together nearly semicircular. Whitish with heavy black or fuscous reticulations on elytra. Vertex with transverse white band interrupted by longitudinal median stripe. Front with irregular arcs at sides, breaking into irrorations on disc. Length, ♂ 4.75 mm.; ♀, 5 mm.

Western Tennessee, Kansas, Colorado, Texas, Oregon; "South to southern Mexico." Ball.

Phlepsius mexicanus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 385, (1918).

"Closely resembling *P. areolatus*, but quite distinct in shape of vertex and genitalia. A stout species with the brownish fuscous irrorations irregularly distributed, leaving patches of milk white. Length 6.75 mm.; width 3 mm.

Vertex convex, with the front almost conical, nearly half longer on middle than against eye, almost three times wider than long, front broad wedge-shaped, but little longer than its basal width. Elytra broad and short, the apices appressed; apical cells short. ♀ segment reduced, less than two-thirds as wide as the penultimate, consisting of an obtusely triangular plate with the apex produced into a strap-like tooth as long as the segment. A pair of broad plates arising under this segment cover the base of the pygofers and a pair of heavy folds occupy the corners. ♂ valve rounding, plates narrow, scarcely as wide as the valve, concavely narrowing to the blunt points, two and one-half times as long as the valve, not quite as long as the compressed pygofers. Vertex testaceous brown, three irregular blotches on the anterior margin and numerous dots on the disc pale; pronotum testaceous brown, with irregular hieroglyphic light markings on anterior half and light pustulate spots on the remainder. Scutellum with the apex and two marginal spots light. Elytra milky white, the nervures fuscous brown, the vermiculation mostly coalesced into fuscous dots which are larger toward the margins."

Described from Orizaba and Chilpancingo Mexico.

Phlepsius distinctus Lathrop (Pl. XXII, Fig. 2).

Head narrower than pronotum, vertex narrow, subangulate, about one-third longer on middle than next eye, rounding to front. ♀ segment slightly longer than preceding, shallowly emarginate. Ivory white with heavy blackish maculations and blackish irrorations, three con-

spicuous lobate commisural spots white, containing minute black spots in the margin, corium with numerous white areas, front irrorations blending irregularly with arcs scarcely indicated. Length, 5 mm.

South Carolina (Lathrop), North Carolina, Florida, Mississippi (H. O.).

Phlepsius graphicus Ball. (Pl. XXXII, Fig. 5).

Somewhat similar to *decorus*, but paler and with the commissural lobes less pronounced. Head short; vertex one-fourth longer at middle than next the eye; front broad, sinuate, roundingly narrowed from antennal pits; clypeus twice as long as wide; loræ large, almost reaching margin of cheek. Pronotum twice as long as vertex; elytra broad, tapering, slightly flaring. ♀, last ventral segment twice as long as preceding; hind border sinuate and deeply notched at the middle, with a prominent tooth each side the median notch formed by a distinct incision; lateral angles sloping, rounded. ♂ valve short, obtusely angular behind; plates short; outer margins convex; tips blunt, a little more than half as long as pygofer. Yellowish-gray, with vertex, pronotum and scutellum faintly irrorate with pale fuscous or brownish; elytra with rather dense ramose lines and dots; veins fuscous. Beneath pale yellowish; legs spotted. Length, ♀, 6 mm.; ♂, 5.5 mm.

Ft. Collins, Colo.; Kimball, Neb.

Phlepsius annulatus n. sp. (Pl. XXXII, Fig. 3).

Somewhat similar to *decorus*, smaller, tinged with rosaceous, female segment with a square excavation on the posterior third. Head narrower than pronotum, vertex narrow, convex, sloping anteriorly, one-third longer on middle than next the eye, margin obtuse, almost rounded. Ocelli close to the eye. Front scarcely convex, narrowing gradually to the clypeus, cheeks scarcely sinuate beneath the eye. Pronotum strongly arched in front, lateral carina equalling short diameter of eye. Claval veins approaching each other with a cross vein in middle. ♀ segment short, a deep quadrangular excavation on the middle, lateral lobes sinuous and lateral angles rounded. ♂ valve small, angled; plates convex, nearly semicircular, nearly reaching tip of pygofer. Vertex, pronotum and scutellum and inner border of clavus yellowish, more or less irrorate with fuscous. Elytra milky white or hyaline, marked with dark brown and fuscous, female with conspicuous spots at ends of claval nervures. In the male these are less conspicuous, but the pigment lines in the elytral cells appear more numerous. A number of distinct dark patches appear in the costal cells. A rosaceous tinge on elytra of female. Face dark fuscous with yellowish dots, about four oblique arcs on the front. Two distinct fuscous spots on base of clypeus. Legs yellowish, conspicuously annulated with black. Length, ♀ 5.5, ♂ 5 mm.

Described from one female from the base of Mt. Hood, and one male from Alsea Mt., Oregon. (Lathrop). On undergrowth at edge of fir forest.

Phlepsius notatipes n. sp. (Pl. XXXII, Fig. 4).

Similar to *decorus* in size and pattern, but paler and with the legs marked with numerous black dots, those of the femora in longitudinal series. Head narrower than pronotum, short, faintly angulate; vertex slightly longer at middle than next the eye; front broad at base; lateral margin somewhat convex; clypeus widened at tip; loræ large, nearly touching margin of cheek; cheeks broad, distinctly sinuate. Pronotum twice as long as vertex, broadly rounded before, faintly concave behind; elytra short, broad, rounded at tip, slightly longer than abdomen. ♀ last ventral segment short, scarcely longer than preceding; hind border sinuate, slightly produced toward the center, a deep median notch, outside of which is a shallow notch just inside the produced part. ♂ valve small, obtusely angulate behind; plates short, sub-triangular; outer border slightly convex; tips bluntly angular, reaching about two-thirds of the way to the tip of the densely setose pygofer. Light gray; vertex with a faint fuscous pattern of minute irrorations; front dark fuscous with numerous dots and irregular arcs; a few dots on loræ and cheeks. Pronotum, scutellum and elytra with minute fuscous or blackish irrorations and lines; the claval border with three faint ivory white lobes, including minute black lines; the tips of claval veins black. Beneath gray; legs minutely dotted with fuscous and black; the female segment margined with light fuscous; pygofer dotted with light. Length, ♀, 5.75 mm.; ♂, 5.5 mm.

Described from three females, (type and paratypes), and one male, (allotype), collected by F. H. Lathrop at Pullman, Washington, August 11, 1919. On dry hillside, from grass.

Phlepsius hosanus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 386, (1918).

"Form and general appearance of *decorus* O. & B., slightly smaller and with a definite concave light line between the ocelli. Length 6 mm., width 2.5 mm.

"Vertex transversely convex, slightly sloping to the narrow margin, one-fifth longer on middle than against eye, twice wider than long. Front moderately broad above, wedge-shaped, distinctly longer than wide. Pronotum but little wider than across the eyes. Elytra longer and more flaring than in *decorus*. ♀ segment short, posterior margin nearly truncate with four triangular teeth on the middle third, the outer pair the larger. Vertex brownish fuscous; a spot at apex, the line between ocelli and the base ivory white. Pronotum with tawny markings on the anterior third. Scutellum tawny with light and black spots. Elytra ivory white, with fuscous irrorations coalescing into irregular spots, omitting the inner margin back to apex of clavus. This ivory margin is narrow next the scutellum and is crossed by the inner claval nervure. It widens out on middle of clavus and again before apex and usually bears one or more black spots in each expansion."

Described from Orizaba, V. C. and Tepetlapa Guerrero, Mexico.

Phlepsius decorus O. & B. (Fig. 9).

Robust, elytra flaring, head narrower than pronotum; vertex broadly, roundingly angulate, about one-third longer on middle than against eyes, anterior margin bluntly angulate. Front in profile scarcely convex. ♀ segment slightly longer than preceding, hind border truncate with a deep circular notch bordered with brown. ♂ valve small, rounding behind, plates short, triangular, acute at apex. Dull ivory white, tinged with tawny on head, pronotum and scutellum; vertex irrorate with fuscous, with transverse whitish band extended forward to apex at middle, inner margin of elytra ivory white, broadening into lobes on the sutural margin. Front with short fuscous arcs merging into confused irrorations on central portion.

Iowa, Illinois, Ohio, New York, Maine, North Carolina, Tennessee, Florida.

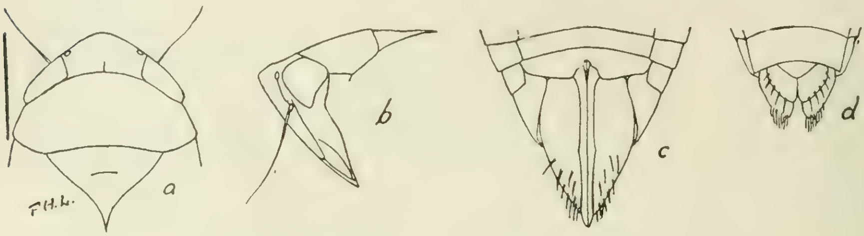


Fig. 9. Phlepsius decorus Osb. and Ball.
a, dorsal view; *b*, profile; *c*, ♀; *d*, ♂.

Phlepsius areolatus Baker. (Pl. XXIV, Fig. 2).

Head narrower than pronotum; vertex subangulate, one-third longer on middle than against the eyes, anterior edge sharp, front straight in profile. ♀ segment twice as long as preceding, hind border nearly truncate, slight notch on middle. Ivory white, distinctly tessellate with brown, fuscous and black irrorations or maculations; anterior border of vertex with alternating ivory and black spots, frontal arcs slender, irregular, merging on middle. Length, 6 mm.

Kansas.

Sub genus Iowanus Ball.

Phlepsius spatulatus VanD. (Pl. XXXIII, Fig. 1).

Head narrower than prothorax; body long, slender, vertex one-half longer on middle than next eye, rounding to front, front slightly convex in profile; elytral reticulation rather coarse, less distinct than in *majestus;* elytra long, narrow. ♀ segment longer than penultimate, slightly produced on middle, with slight median notch. ♂ valve short, roundingly angular behind; plates narrow, tapering nearly uniformly to acute tips. Ashy brown; vertex with mottled transverse band between eyes, in front of which are two triangular mottled spots.

Frontal arcs irregular, meeting on middle. Length, ♂, 6.5–7 mm.; ♀, 7 mm.

Colorado, California, Kansas, Texas, Mexico, along the border, to Central Mexico. Two specimens (Osborn collection) from the Canal Zone.

Phlepsius spatulatus, var. **personatus** Baker.

This form differs from the typical *spatulatus* in being light colored, pale gray or whitish, with faint dots and irrorations with a fairly distinct fuscous band between the eyes and a distinct black dot on the base of the last ventral segment of the female. The genitalia seem to agree entirely with *spatulatus* and the color differences too variable to warrant the separation as a distinct species.

Phlepsius sabinus, Sanders & DeLong.

Penna. Dept. Ag., Vol. III, p. 15, 1920.

Similar to *spatulatus*, but darker; head narrower than pronotum, distinctly produced, bluntly angled; vertex one-half longer at middle than next the eye. Pronotum strongly arched; elytra long, narrow. ♀ last ventral segment two and one-half times length of preceding, margin truncate with median broad bifid tooth, nearly one-third length of segment. Vertex white toward apex, with broad, irregular black band between eyes, brown posteriorly, and two black triangular spots toward apex. Pronotum pale, variously mottled and splashed with brown, numerous tiny punctures most abundant posteriorly. Lateral margins bordered with white. Scutellum brown mottled anteriorly and pale posteriorly. Elytra milky white, irregularly inscribed and mottled with dark brown pigment. Face pale buff, with nine or ten pairs of irregular brownish arcs, a broad median pale line and with black band at base of clypeus. Margin of frons near antennæ, irregular spot and broad line below eyes extending across pronotum below margin black. Venter pale beneath, except first abdominal segment and sometimes a broad median band, black.

Arizona.

Phlepsius denticulus n. sp. (Pl. XXIV, Fig. 4).

Similar to *ovatus*, but smaller; head more distinctly angulate and genitalia different.

Head narrower than pronotum; vertex distinctly angulate, nearly twice as long at middle as next the eye, rounded to front; front broad at base, narrowing nearly uniformly to clypeus; clypeus about twice as long as broad, expanded at tip; loræ large; cheeks expanded at sides, margins distinctly sinuate. Pronotum about half longer than vertex; lateral carina about one-half the length of the eye, hind border slightly concave; elytra broad, slightly flaring at tip. ♀ last ventral segment with a pair of rather strong teeth divided by a median notch, lateral angles produced into blunt teeth. ♂ similar to superbus; valve small,

angled behind; plates short, broad, bluntly rounded behind, about one-half as long as pygofer, not as nearly semicircular as in superbus. Dull gray, tinged with brown; vertex and pronotum faintly irrorate with fuscous; scutellum with a central dark line; elytra gray, subhyaline, with fuscous ramose lines more or less distinct; costal border with a series of dark spots more pronounced at tip; front brownish or light fuscous, with pale arcs and dots; clypeus pale, with a median darker stripe; loræ with dark spots on the disk; abdomen above blackish, below dark gray; legs light brownish with fuscous annulations and dots. Length, ♀, 4.25–4.75 mm.; ♂, 4–4.5 mm.

Described from a series of eleven specimens, four females and seven males, Los Banos, California, May 23, 1918, collected by E. P. Van Duzee.

This species has considerable appearance of a minute and light colored *superbus*, but has a longer vertex and the female segment is decidedly different, while the male plates are similar to that species.

Phlepsius neomexicanus Baker. (Pl. XXXIII, Fig. 2).

Head distinctly narrower than pronotum; vertex about one-third longer on middle than at eye; edge subacute, front slightly convex in profile, front broader than in spatulatus; elytral reticulations coarse. ♂ valve narrow, short, distinctly obtusely angulate; plates broad at base, narrowing behind center, extending into acute tips reaching half way to extremity of large, remarkably elongated, pygofers. Ash gray, fuscous irrorations, vertex light gray with faint, central, broken line, anterior margin with faint irregular brownish marks and circular dots, fairly dark cresentic spots on anterior border of pronotum, frontal arcs indicated by light maculations on brownish base. Length, 6 mm.

New Mexico.

Phlepsius incurvatus n. sp. (Pl. XXXIII, Fig. 3).

Head narrower than pronotum, distinctly angulate, subconic; vertex a little wider than length at middle, nearly twice as long at middle as next the eye, rounded to front, more acute at apex; front rather narrow, tapering to clypeus; clypeus scarcely widening toward tip; loræ large, elongate, nearly reaching tip of clypeus; cheeks narrow, distinctly narrowed below. Pronotum strongly arched in front, two-thirds longer than vertex, hind border concave. ♀ segment deeply incurved at middle, only about half as long as preceding segment. ♂ valve small, triangular; plates broad at base, sinuate; tips narrow, acute, reaching two-thirds length of the pygofer; pygofer large, not as long as in *neomexicanus*. Light gray, more or less irrorate with fuscous; vertex, pronotum and scutellum pale; front dusky, mottled; clypeus mottled with pale fuscous; elytra whitish, sub-hyaline, distinctly inscribed with fuscous and black lines; the claval veins at tips, and costal cross-veins conspicuous. Length, ♀, 5.75 mm.; ♂, 5.5 mm.

Two specimens, male and female, Sabino Canyon, Catalina Mountains, Arizona, 518, E. P. Van Duzee collection; one specimen, female, Imperial County, California, R. Hopping, Collector, E. P. Van Duzee collection.

Phlepsius cinerosus n. sp. (Pl. XXXIII, Fig. 4).

This species is apparently most closely related to *spatulatus* and *neomexicanus*, but may be distinguished by its smaller size, its pale color, absence of color markings and different genitalia. Vertex narrower than in spatulatus; angulate, half longer at middle than next the eye, genæ distinctly sinuate below the eyes. ♂ valve obtusely triangular; plates long, broadest on the base, narrowing on the basal region, tips together broadly rounded. Pygofers somewhat exceeding the plates laterally. ♀ segment nearly three times the length of the preceding; moderately narrowed posteriorly, the posterior margin almost truncate with a triangular notch in the middle. Faded yellowish, approaching *cinereus*. Vertex with a few, rather obsolete deep yellow markings. Eyes fuscous. A number of arcs on the front, the genæ below the eyes, and spot on the lora and clypeus, fuscous. Pronotum and scutellum practically without markings, and the reticulations of the elytra all but obsolete. Length, 6 mm.

Described from one female (type) and one male (allotype) from Springer, N. M., collected by C. N. Ainslie. Types in National Museum.

Phlepsius delicatus n. sp. (Pl. XXXIII, Fig. 5).

Very light gray, faintly marked with delicate ramose veins. Head a little narrower than pronotum; vertex broad, about one-third longer at middle than next the eye, obtusely angulate, rounded to front; front broad, roundingly narrowed to clypeus; clypeus twice as long as width at base, distinctly widened toward the tip; loræ large, almost touching margin of cheek; cheek margin distinctly sinuate. Pronotum twice as long as vertex, lateral margin one-half as long as eye, distinctly carinate; hind border slightly concave; elytra moderately broad, slightly flaring toward the tip. ♀ segment short, concave; lateral angles prominent similar in form to superbus. Light gray or whitish; vertex and pronotum faintly irrorate with darker gray; elytra milky white, delicately inscribed with ramose lines, a larger dark dot at ends of claval veins, and a series of dots on costal border. Beneath and legs pale gray or whitish, the fore femora and all tibiæ externally dotted with black. Length, 5 mm.

Described from one specimen, female, (type), collected by E. P. Van Duzee at Palm Springs, California, May 21, 1917.

Phlepsius elongatus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 382, (1918).

"Resembling *majestus*, but narrower with a longer, flatter vertex and a long acuminate female segment. Vertex transversely depressed, nearly flat on anterior half, acutely angled with the long narrow front, one-third longer on middle than against eye, half wider than long. Pronotum much wider than vertex, the outer angles prominent. Elytra very long and narrow. ♀ segment continuing full width as long as the penultimate, then tapering into a long, slender point extending almost to apex of pygofers. Vertex pale testaceous; the anterior third black except for a narrow light margin and a median line; a spot against either eye near the base and an irregular band on middle brownish or fuscous. Front pale, with fuscous arcs, the upper pair very distinct and margining the vertex, below they coalesce into an irregular spot on the disc. Pronotum pale, irregularly mottled with brown, three fairly definite fuscous spots on the anterior sub-margin behind each eye. Scutellum fulvous, with six light points. Elytra pale, fulvous, uniformly inscribed with testaceous.. Length, ♀, 10 mm."

Described from a single female from Mexico.

Phlepsius handlirschi Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 383, (1918). Fig. 3b, c and d.

Form and general appearance of *majestus* Osborn and Ball. Slightly smaller and with a narrower vertex. General color, fulvous brown. Vertex pale yellow with a broad band and two sub-apical spots black. Vertex and face as in *hebraeus*. Elytra slightly broader and less flaring, second and third apical cells long and curved. ♀ segment short, transverse; posterior margin nearly straight, the median third produced on each side of a narrow median notch extending over half way to the base; angles next this notch acute. ♂ valve semicircular, plates long, acutely triangular, the extreme tips rounding, three times as long as the valve. Vertex pale yellow, a transverse band behind the ocelli widening on the disc and interrupted in the middle, and a pair of spots in front of this, black; this band incloses a yellow dot against each eye. Face pale sordid yellow. Short brown arcs on front and a dark ocellate spot on clypeus. Pronotum pale, coarsely irrorate with fulvous brown, the anterior sub-margin with coarse ocellate dark spots. Elytra pale, rather sparsely inscribed with fulvous; three dark spots along the suture. Length, 9–10 mm. (Adapted from Ball.)

Described from Mexico.

Phlepsius hebraeus Ball.

Ann. Ent. Soc. Am., Vol. XI, p. 383, (1918).

Resembling *handlirschi* in general form and appearance, slightly smaller; color and marking similar but slightly paler. Vertex transversely convex, one-fourth longer on middle than against eye, twice

wider than long, the anterior margin bluntly rounding to front; front long and narrow, the margin straight to just before the apex. Pronotum broad, the outer angle sharp. Elytra long and narrow; the anteapical cells parallel margined, a number of extra cells on the costa opposite the anteapicals. ♀ segment moderately long, posterior margin slightly concave with a small semi-circular median notch. Vertex and face marked as in *handlirschi* and *majestus*. Pronotum pale, irrorate with brown and with a few black spots along the anterior sub-margin. Elytra as in *handlirschi*, but lacking the rufous cast and usually with a few definite light spots in the apical cells. Length, 8.5–9 mm. (Ball.)

Described from Mexico.

Phlepsius majestus O. & B. (Pl. XXII, Fig. 4).

This is the largest species of the genus, and may be easily distinguished from the other forms by its size and rich tawny color. Vertex twice as long, scarcely impressed on the disc; front long and narrow, apical suture obsolete. Elytra long and narrow. ♀, ultimate ventral segment scarcely twice the length of the penultimate; the posterior margin shallowly sinuate on each side of a median cleft; the lateral angles prominent, broadly rounding. ♂, valve narrower than the ultimate segment, the apex truncate; plates rather long, triangular, the tips together, broadly rounding; the lateral margins thickly set with thin spines; pygofers exceeding the plates laterally, clothed with spines. Vertex pale with a conspicuous irregular, transverse fuscous band on the middle. Face pale, with the sutures and a number of arcs on the front fuscous; genæ with obscure fulvous blotches. The fulvous markings on the pronotum and scutellum and the prominent fulvous reticulations on the elytra, give the insect a rich fulvous or tawny color. Length, ♀, 9.5–10 mm.; ♂, 9–9.5 mm.

Iowa, Ohio, New Jersey, North Carolina, Texas. On grass in open woods.

EXPLANATION OF PLATES.

Plate XXII.

Fig. 1. Phlepsius carolinus. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron.
Fig. 2. Phlepsius distinctus. *a*, dorsal view; *b*, profile; *c*, face; d, ♀; *e*, elytron.
Fig. 3. Phlepsius slossoni. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron.
Fig. 4. Phlepsius majestus. *a*, dorsal view; *b*, profile; *c*, face; *d*, ♀; *e*, elytron; *f*, ♂.

Plate XXIII.

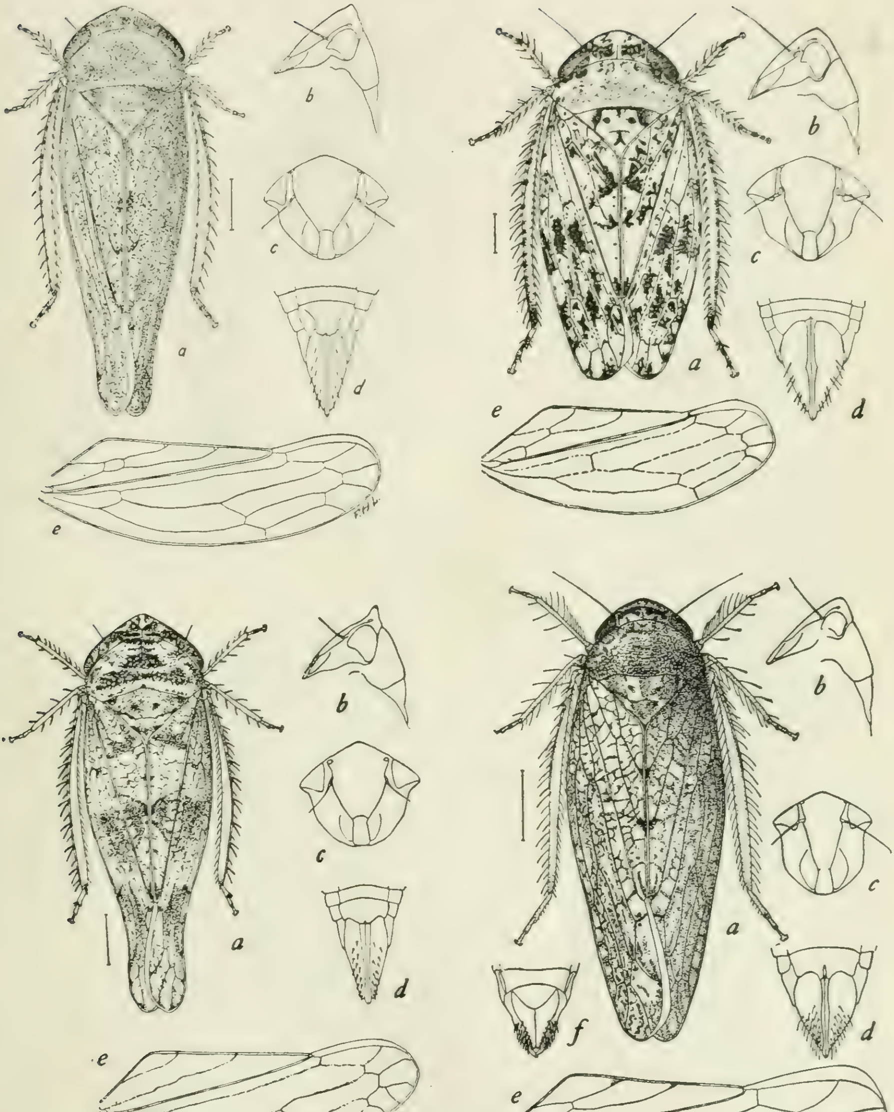
Fig. 1. Phlepsius maculosus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.
Fig. 2. Phlepsius excultus. *a*, face; *b*, ♀; *c*, elytron.
Fig. 3. Phlepsius micronotatus. *a*, profile; *b*, face; *c*, ♀; *d*, ♂; *e*, elytron.
Fig. 4. Phlepsius nebulosus. *a*, profile; *b*, face; *c*, ♀; *d*, ♂; *e*, elytron.

Plate XXIV.

Fig. 1. Phlepsius lobatus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.
Fig. 2. Phlepsius areolatus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.
Fig. 3. Phlepsius eburneolus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.
Fig. 4. Phlepsius denticulus. *a*, profile; *b*, face; *c*, ♀; *d*, elytron.

Plates XXV to XXXIII.

In these plates cited in text, the name of each species is entered under the figures which show: *a*, dorsal view of head and pronotum; *b*, profile; *c*, ♀; *d*, ♂ genitalia. A detailed explanation is therefore unnecessary.



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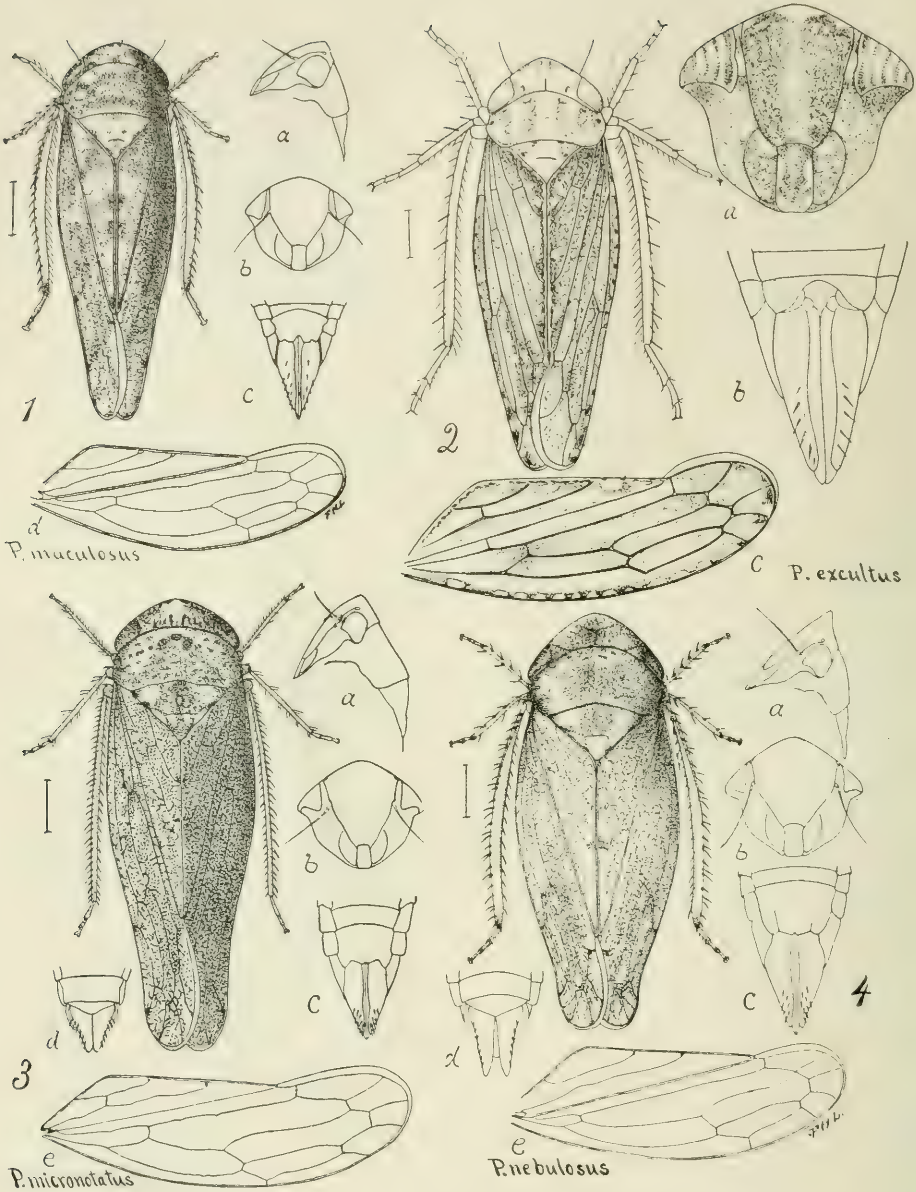

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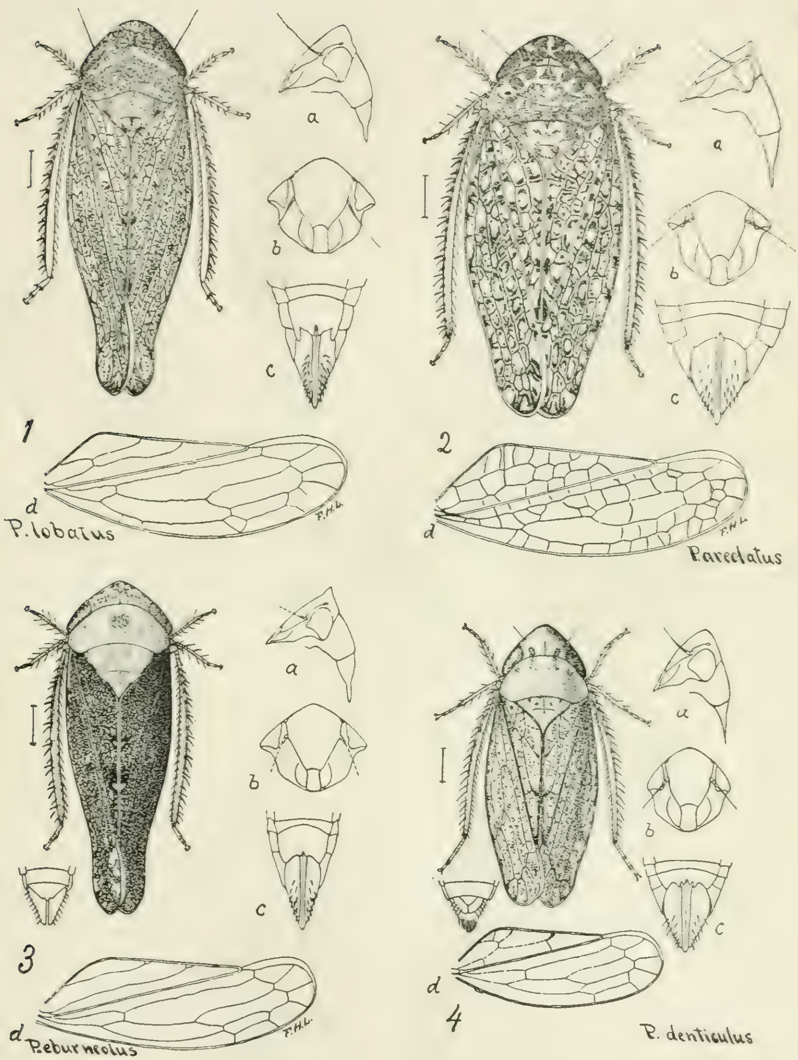

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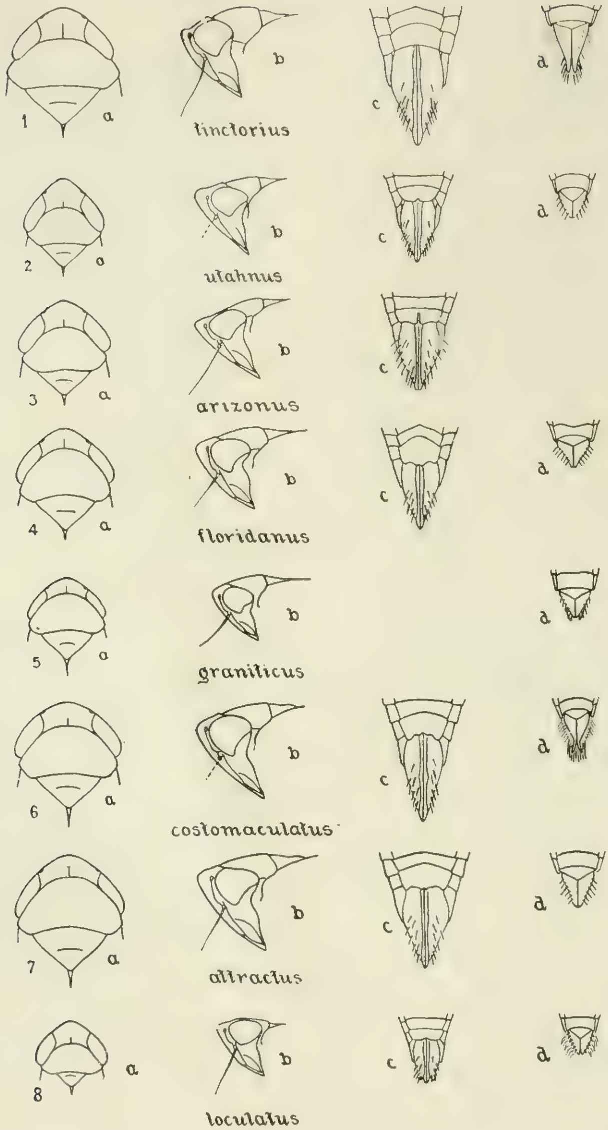
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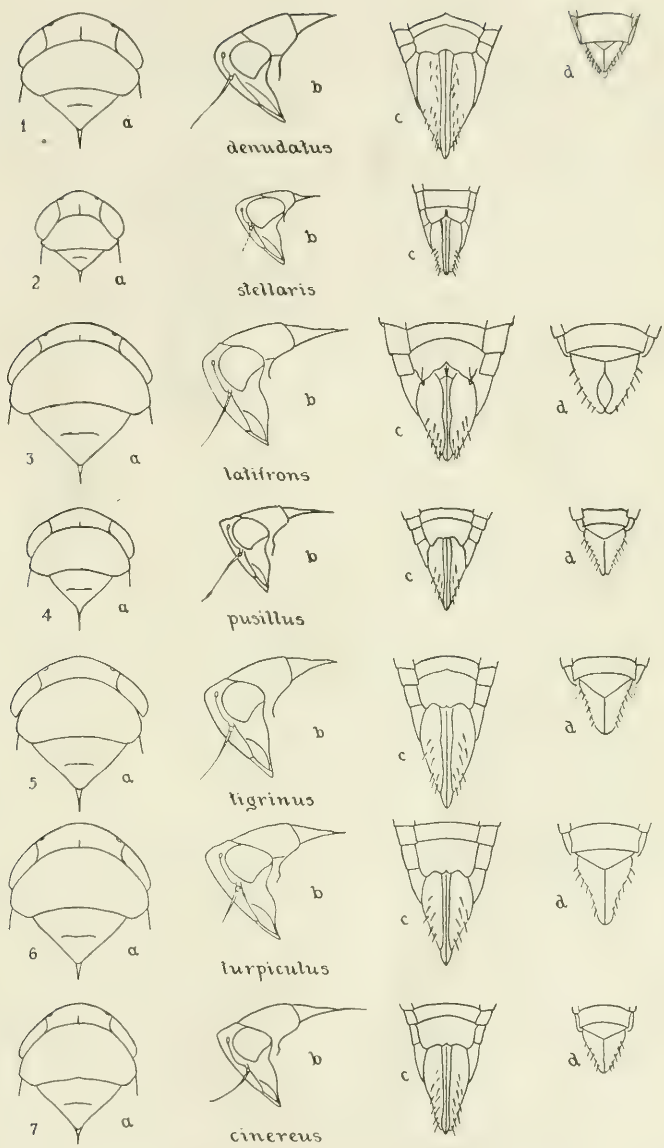

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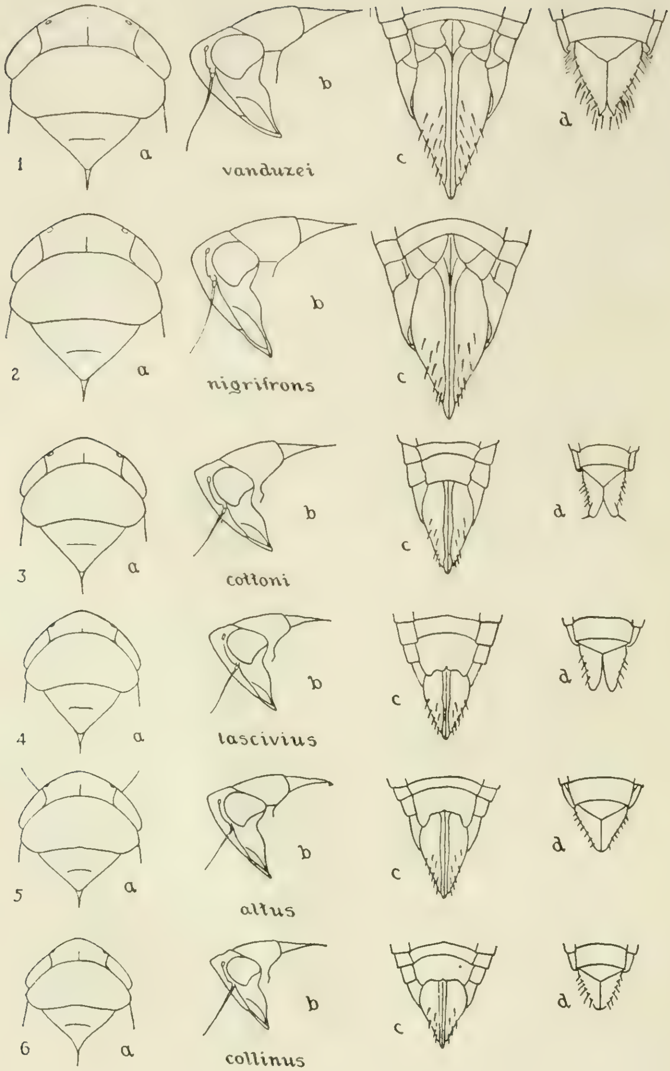

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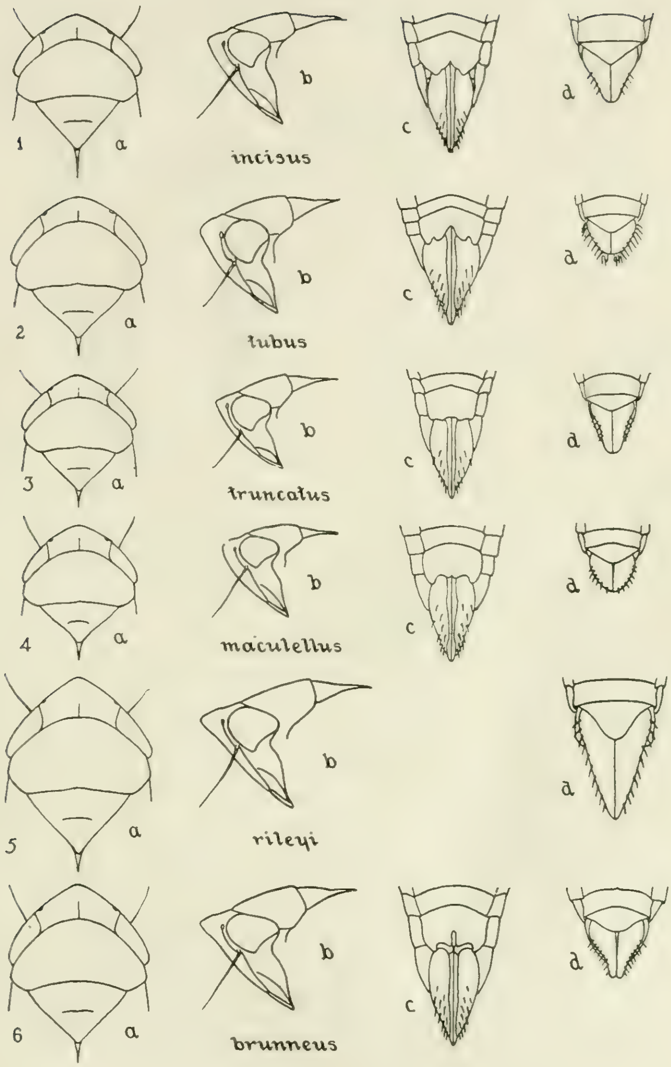

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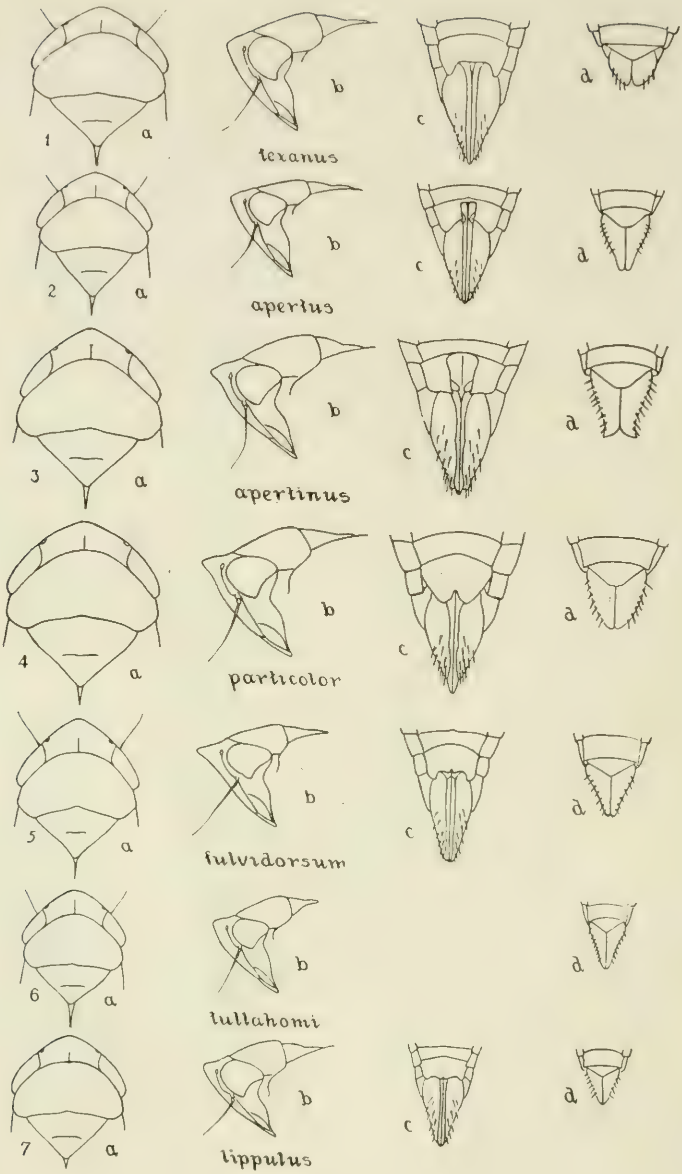

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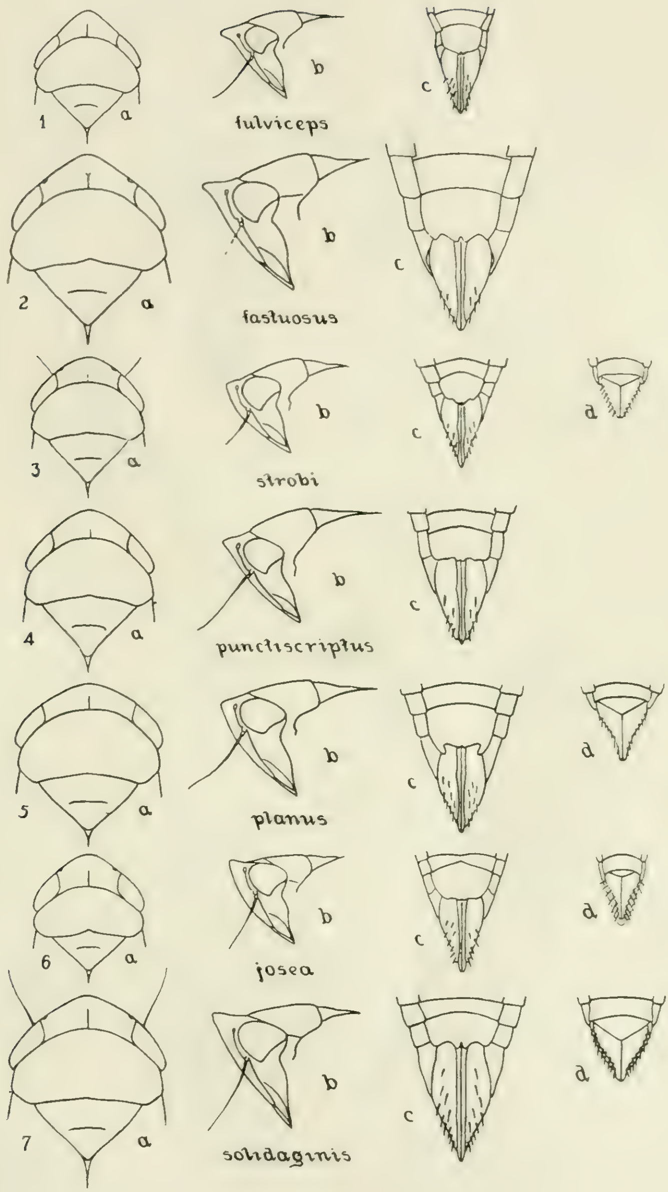

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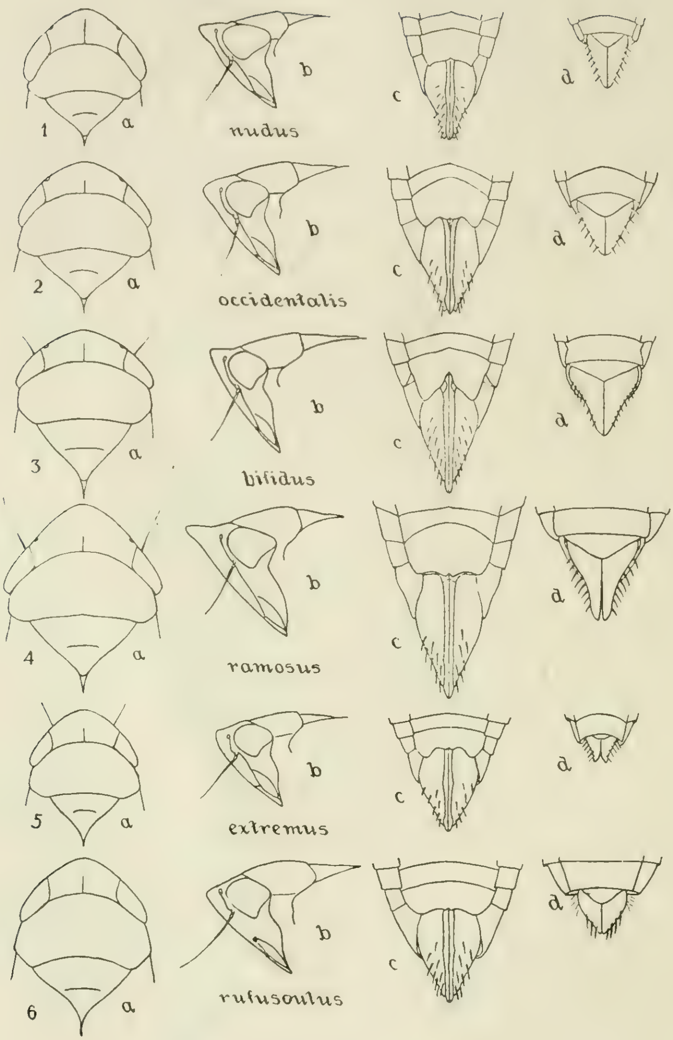

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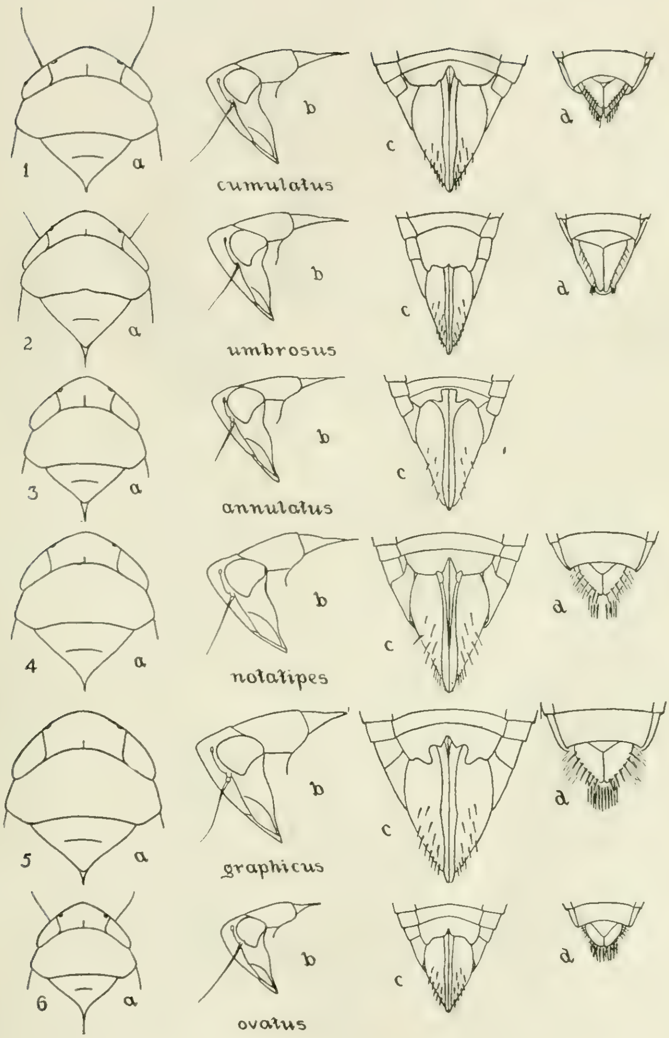

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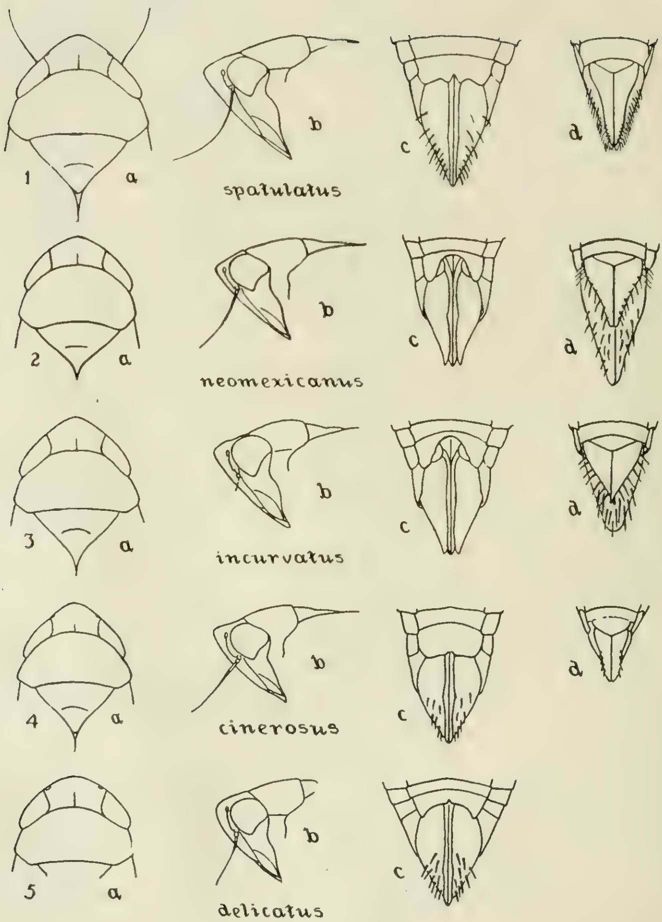

Osborn and Lathrop

THE DISTRIBUTION OF THE LEAFHOPPERS OF PRESQUE ISLE, PA. AND THEIR RELATION TO PLANT FORMATIONS*

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The relation existing between insects and plants and especially the synchronous changes in abundance and succession that accompanies changes in habitat conditions is of both interest and importance to workers in certain groups. It is interesting to know under what conditions an insect lives, and if the habitat and specific food plants are variable in different regions. But these data are usually very hard to obtain in disturbed areas as a complication of conditions and a mixture of food plants may occur. Presque Isle has furnished an ideal place for such a study because the zones and stages of plant associations, and their successions are so well defined. Consequently a record of specimens captured and a study of existing conditions there may be of interest to others.

The Island, or peninsula as it might better be called, is a projection extending some six miles north-east from the mainland at Erie, Pennsylvania, and is more than three miles wide at its broadest portion, the eastern extremity. The entire formation is the result of wave action, and since it has accumulated over a period of many years, all stages and conditions in plant successions of this region are found there. The older portion is covered with a deciduous forest, more recently constructed areas with pine forests, shrub stages, bog and heath, and the new portions with sand plains, dunes, marshes and numerous lagoons in various stages of succession. Although insects do not have such well defined successions of associations as do plants, they do have certain very definite relations with certain plant associations and as these constantly change from one stage to another, we find for the most part a different group of insects accompanying each successive plant association.

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*Contribution from the Department of Zoology and Entomology of The Ohio State University, No. 74.

The portion of this area which has been studied more thoroughly is the broad eastern extremity or sand plain area with its numerous lagoons and marshes in all successional stages. Some study was also made at the head where the peninsula connects with the mainland. Only a brief resume of these habitats will be given in the following pages together with their respective findings.

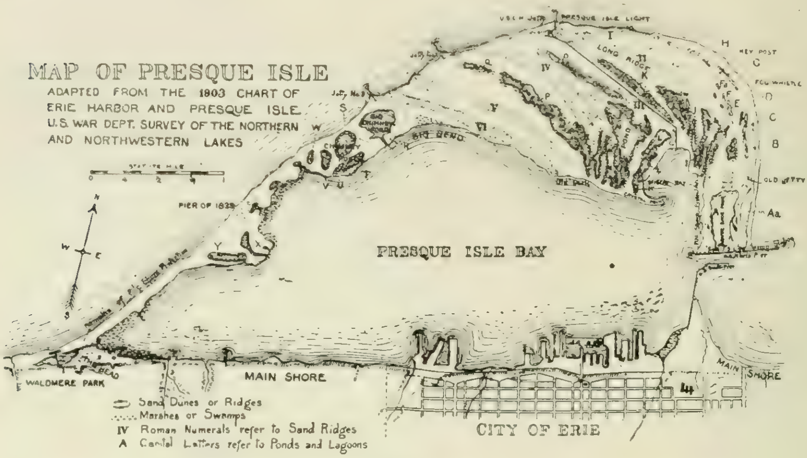


FIG. 1.
Map of Presque Isle, Pennsylvania, showing physiographic conditions.

A detailed study of the plants of Presque Isle has been made by Dr. O. E. Jennings and his excellent outline of the plant associations and successions has been followed in this report. Only the leafhoppers belonging to the Cicadellidæ (Homoptera) have been studied because of the author's familiarity with the group and also in order to obtain more specific results regarding their relationships to plant associations and formations. Although many other insects were collected in these habitats, no consideration is given to them at this time.

THE BEACH-SAND PLAIN-HEATH-FOREST SUCCESSION.

The beach is practically devoid of leafhoppers and although an occasional specimen of *Cicadula 6-notata* or some other cosmopolitan feeder may be found here, these are probably accidental records and the insects have no definite relationship to the meager vegetation that is able to withstand the storm and wave action.

The sand plain occupies large areas of the eastern extremity. The vegetation of the sand plain proper is very uniform and composed of a few predominant species. One of these grasses *Andropogon furcatus*, (a climax plant of the prairie) is abundant and usually found growing in clumps throughout this portion of the island (Plate XXXIV, Fig. 4). *Thamnotettix pallidulus* Osb. has been taken abundantly from this grass and seems to be restricted to it as a food plant. This is a western species described from Iowa in 1898. A recent citation from Kansas is the only record since its original description and it has not been reported previously east of the Mississippi River.

Large areas of scattered tufts of *Panicum* also occur on the sand plain (Plate XXXV, Fig. 3). Two species are especially abundant, *Panicum villosissimum* and *P. hauchucæ*, and are some what intermingled. Both of these appear to be food plants of *Deltocephalus apicatus* Osb. which was taken in abundance at various intervals during the summer both as adult and nymph. Other species commonly found on the sand plain are *Deltocephalus inimicus*, *sayi* and *misellus* and *Phlepsius irroratus*.

Dr. Jennings has shown that there may be a heath or a *Myrica* thicket association in the beach—forest succession. Where the *Arctostaphylos-juniperus* Heath Association occurs, only a few leafhoppers are found. *Gypona octolineata* and *rugosa* have both been taken from a uniform and pure society of *Arctostaphylos*. In case a Myrica thicket association follows the sand plain, another group of insects occurs. Such species as *Empoasca flavescens* and *Balclutha impictus* are found on the *Myrica*, *Graphocephala coccinea* is abundant as nymph and adult on species of *Rubus*, *Deltocephalus configuratus* on *Poa compressa* and usually *Empoasca atrolabes* and *Oncopsis variabilis* are always present on *Alnus*.

The *Quercus velutina* Forest formation has not been worked in detail for the leafhopper species. A few observations have been made however. Several species of *Erythroneura*, *Empoa* and *Empoasca* occur on *Quercus* and *Acer*. *Jassus olitorius* is apparently confined to Sassafras as its food plant. *Gypona pectoralis* and *Alebra albostriella* are very common on *Tilia americana*. *Erythroneura tricincta*, *vitis*, *vulnerata*, and *comes* are common on species of *Vitis*.

On the herbaceous layer many common species as *Scaphoideus immistus* and *auroniteus*, *Balclutha osborni*, *Deltocephalus*

sayi and *inimicus*, *Phlepsius irroratus* and *Cicadula 6-notata* are found. Other species less abundant as *Mesamia vitellina* live on the herbaceous vegetation and *Scaphoideus lobatus* was found as nymph and adult feeding upon *Solidago cæsia*.

The leafhopper species do not differ greatly from the preceding in the associations of the Dune-Thicket Forest Succession, undoubtedly due to the fact that about the same plants are found in these associations as those mentioned above. Many of the plants of the sand plain such as *Ammophila* and *Andropogon* are common on the dunes and numerous grass feeding forms mentioned above occur on these plants. Where dunes are built up by the cottonwood, *Populus deltoides*, the common poplar species are abundant, among which *Empoasca trifasciata*, *Idiocerus lachrymalis* and *I. suturalis* are usually present.

The *Rhus-Toxicodendron*-Thicket-Association is frequently so dense and entangled that it is very difficult to cut a path through it. Large areas of long ridge, especially, are covered with this dense growth. Several species of common insects were found in this habitat, many of them the same as those occurring on the sand plain.

THE LAGOON-MARSH-THICKET-FOREST SUCCESSION.

The areas by far the richest both in individuals and species are the moist areas in the marshes and along the lagoon margins. A great number of lagoons are present and represent all stages in development from a pool of clear water in the midst of a sandy expanse, bordered by practically no vegetation, to ponds of arrow weed and marshes entirely filled with sedges. It is surprising how these different types of lagoons will vary in their "Jassid" fauna.

The willows and poplars are apparently the first plants to come in at the margins of the lagoons. During their first few years no leafhoppers could be found upon them. Later, however, when the zones are greatly pronounced by the thick, shrubby growth, species like *Macropsis viridis*, *M. virescens var. graminea; Idiocerus pallidus*, *Empoasca obtusa*, and *E. flavescens* are found on the willows and *Idiocerus lachrymalis* is common on the poplar shrubs. Another group of plants which are submerged or float upon the water and belong to the *Potamogeton* Association begin to grow in the waters of the lagoon at about the same time. So far as records to date are

concerned, none of these insects are known to live upon the submerged or floating vegetation.

Lagoon Aa is comparatively young perhaps representing an early stage of the lagoon succession which is shown very definitely by the vegetation along the margins. A short tender growth of *Juncus*, *Eleocharis* and small segdes close to the water line furnishes ideal feeding places for *Phlepsius fuscipennis* and *collitus*, *Euscelis parallelus*, *striolus* and *cuneatus* and *Cicadula 6-notata* which are found in abundance on the short vegetation in the narrow zone along the lagoon margin (Plate XXXIV, Fig. 5). Only a few feet from the water line of the lagoon the sand plain vegetation is found and as stated previously, a different group of species is present.

Euscelis cuneatus a very abundant and recently described species lives in company with *Cicadula 6-notata* and *Euscelis striolus* on a uniform mat of *Cyperus diandrus* on a newly formed portion of the island (Plate XXXV, Fig. 4).

In the case of older lagoons such as C. D. and G. representing later stages of the lagoon succession where a wider margin of vegetation occurs, many sedges and grasses grow in the *Typha-Scirpus* and especially the *Sabbatia-Linum* association and several species of *Juncus*, *Eleocharis* and *Scleria* abound. Here we can add to the lagoon species already mentioned, *Thamnotettix melanogaster* and *fitchii*, *Drœculacephala mollipes*, *Helochara communis* and *Phlepsius irroratus*. A marshy area at the end of lagoon Aa contains *Chlorotettix spatulatus* and *Drœculacephala minor* in great abundance.

One of the most interesting captures was the securing of *Dorydiella floridana* in great abundance from *Scleria verticellata* in the *Eleocharis obtusa* association (Plate XXXV, Fig. 2). The nymphs were found feeding on the stems just above the surface of the ground and within the clump. This mode of living may explain the fact that this species is considered as very rare and has seldom been collected. Comparatively few specimens can be obtained with a sweep net but by pulling apart a clump of the sedge, frequently two dozen were secured from a single clump.

It was described in 1897 from Florida and although cited only twice in literature since it has been taken in very few numbers in Massachusetts, New Jersey, Illinois along Lake Michigan, and in a similar lake habitat in South Dakota.

Although found occasionally along the lagoon margin its optimum habitat apparently is on sandy areas far distant from the receding waters of the lagoon but within the old lagoon basin. The nymphs and adults were very abundant in this habitat during the past four seasons. *Phlepsius nebulosus* occurs in good numbers in the same type of place but apparently has a different food plant. *Phlepsius fuscipennis* and *Euscelis parallelus* are also very abundant in the old lagoon basins.

In lagoons E. F. and Fa representing the next stage there are only a few additions to the leafhopper species. More striking is the additional number of Fulgoridæ and Cercopidæ which are found here. Such species as *Pentagramma vittatifrons*, *Philænus lineatus* and species of *Stenocranus* are quite common during July.

Perhaps the last stage is presented by the middle one of the three marshy areas just north of Horseshoe pond. Although water is still found in the center of this old lagoon, it has become very shallow and is composed mostly of a black soggy soil. It is rapidly approaching a true marsh condition. Two rather interesting species were added here to our list of lagoon species. *Cicadula potoria* was living on a mat of very short, fine, *Eleocharis acicularis* (Plate XXXV, Fig. 1) and further study on the island showed that it lived apparently under no other condition. This species was living so close to the soggy black soil that it was almost impossible to sweep specimens into a net. It was described from Iowa by Ball, and Juncus was given as the food plant. It has since been reported from Maine and New York. The other species of interest is *Thamnotettix smithi*, which was abundant on a large patch of *Spartina michauxiana*, forming an outer zone in the same marsh. (Plate XXIV, Fig. 3). It is apparently a northern and western species and the food plant has not been mentioned previously. *Cicadula slossoni* a Juncus species is another addition in this association.

The marsh stage of the lagoon succession is shown by lagoon B and marsh 3 just north of horseshoe pond. Although a little clump of *Typha* still remains, the lagoon basin is almost entirely filled with *Calamagrostis canadensis* (Plate XXXIV, Fig. 1). This is the so-called wet meadow and a large group of species live upon these grasses. The most abundant species found here are *Chlorotettix unicolor*, *spatulatus* and *tergatus*, *Phlepsius irroratus*, *Thamnotettix nigrifrons* and *melanogaster*, *Parabolo-*

cratus major, *Dræculacephala mollipes* and *noveborocensis*, *Deltocephalus inimicus*, *striatus* and *sayi*. *Platymetopius frontalis* and *acutus*, *Mesamia vitellina* and *Scaphoideus ochraceous* occur less abundantly. Perhaps the most interesting species occurring here are *Thamnotettix inornatus*, *Deltocephalus osborni* and *Dikraneura mali* which species do not occur on other plants on the island and are apparently restricted to this habitat. So these may be added to the species of the lagoon succession. In the wet meadow at the west of horseshoe pond *Cicadula pallida* and *Euscelis elongatus* were taken from short grasses in the marshy area (Plate XXXIV, Fig. 6).

A detailed study of these lagoons in various stages has shown that as the vegetation constantly changes in the older lagoons, new species of leafhoppers also work into the association especially where restricted to a single plant for food. The change is perhaps not so pronounced nor so permanent as in the case of the plants, but is nevertheless a different association.

THE BAY-MARSH-THICKET-FOREST SUCCESSION.

At the head of the peninsula between the narrow neck and the mainland, a large and very interesting swamp area is fouud with small patches of marsh and wet meadow at its margins. In this swamp on the *Typha-Scirpus* association, large numbers of *Dræculacephala angulifera* both as nymphs and adults occur on *Scirpus fluviatilis*, the river bulrush (Plate XXXIV, Fig. 2.) Also a large *Cicadula* (apparently undescribed) was present in abundance.

On the *Carex-Phragmites* association which merges with the wet meadow a large number of species of leafhoppers are found. The principal species here are *Dræculacephala mollipes*, *Chlorotettix unicolor*, *Thamnotettix fitchii*, *T. melanogaster* and *Phlepsius solidaginis*. The number and dominance of species, however, will vary with the season and the consequent life cycle. Other common species found here in more or less abundance during the summer are *Platymetopius frontalis* and *P. acutus*, *Euscelis striolus*, *Deltocephalus inimicus*, *D. striatus*, *D. balli*. *Phlepsius irroratus*, *Agallia 4-punctata* and *A. sanguinolenta*. During certain months *Thamnotettix cypraceus* is abundant as nymph and adult upon sedges in a grassy-*Solidago* association which is intermediate between the true wet meadow and the shrub zone. Also *Scaphoideus immistus* and *S. auronitens* are found

here. Several specimens of *Deltocephalus configuratus* were taken from *Poa compressa*.

Where the wet meadow is being invaded by the *Rhus-Alnus* shrub association other leafhoppers are found. Such species as *Oncopsis variabilis*, *Alebra albostriella*, *Empoasca atrolabes* and *Empoa tenerrima* are common and abundant upon *Alnus*.

The *Ulmus-Acer* association was not worked in detail for leafhopper species but two rather interesting observations were made. Where *Solidago cæsia* is found as a member of the ground layer, *Scaphoideus lobatus* was collected in abundance both as nymph and adult. Also on the *Linden*, *Gypona pectoralis* and *Alebra albostriella* were abundant. On the dunes and sand ridges where the poplars form an important part of the vegetation such species as *Idiocerus lachrymalis* and *I. suturalis* are abundant on *Populus deltoides*. *Idiocerus cognatus* is very common on *Populus alba* and the Lombardy poplar is apparently the food plant of *Idiocerus scurra*.

Where the *Salix* shrub zone follows immediately the *Scirpus americana* formation certain species are found feeding upon the willows. *Macropsis viridis*, *M. suturalis*, *M. virescens var graminea*, *Idiocerus pallidus*, *I. snowi*, *I. suturalis*, *Empoasca obtusa* and *E. smaragdula* are the principal species. Also *Empoasca flavescens*, *Thamnotettix clitellarius* and *Eutettix seminudus* are found in less abundance.

This study has been especially interesting for three reasons. First, because the vegetation is arranged in such a way as to give definite zonation, and great extremes of conditions are found in limited areas. Second, several interesting and valuable records of supposedly rare species have seemed to strengthen the theory that a species is considered rare only when its food plant is very scarce or more often when its habitat and mode of living are not known. Third, by studying a group of insects which are plant feeders and by taking only this one group with which study has been carried on for several years, more detailed results were obtained than in the case of a study of all insects or all animals present in a definite habitat, for frequently there is a failure in such cases to distinguish between valuable records and those of minor importance.

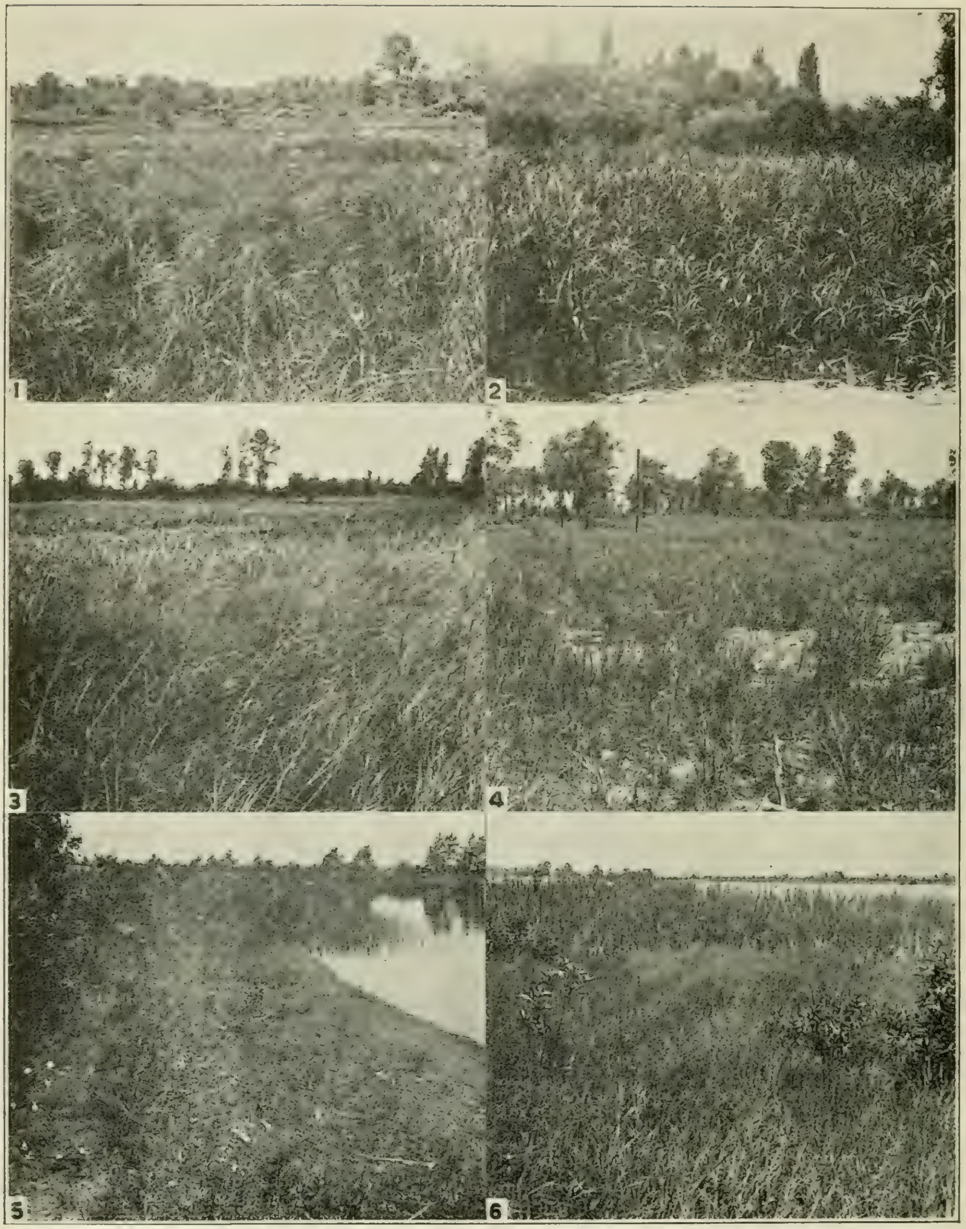
EXPLANATION OF PLATES.

Plate XXXIV.

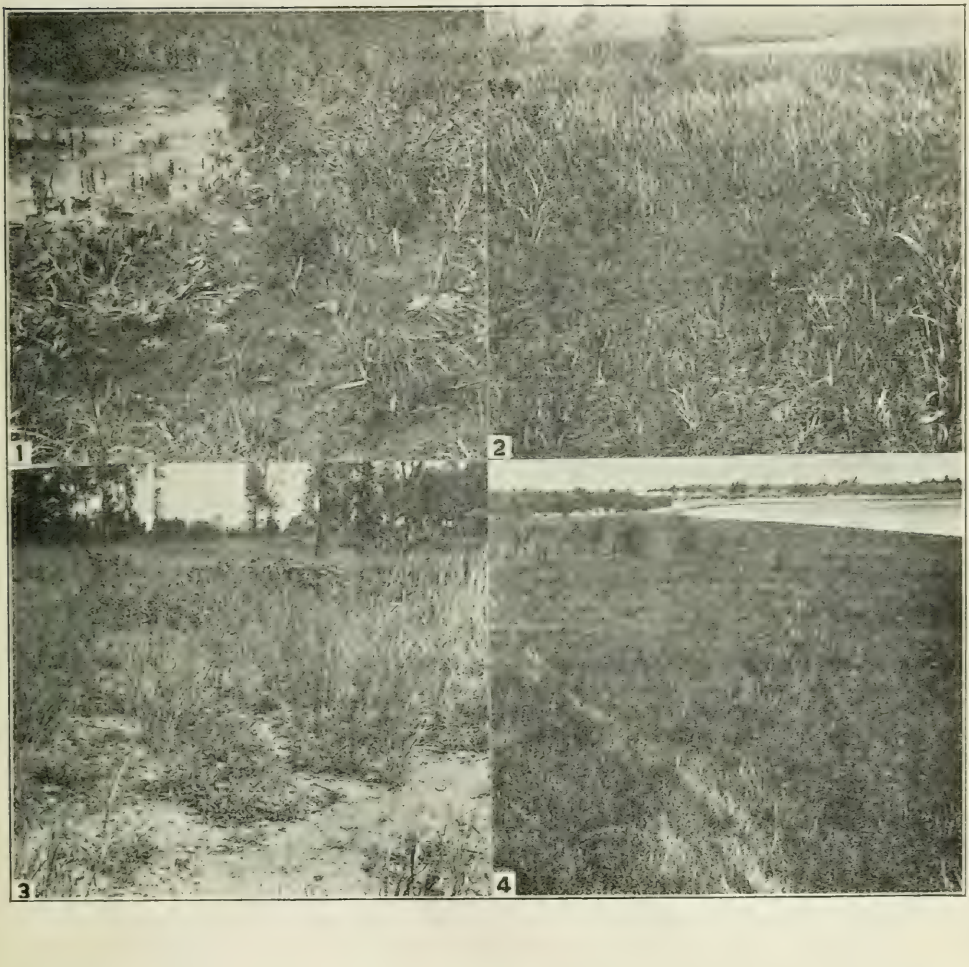
1. Wet meadow filled with *Calamogrostis canadensis.*
2. Association of *Scirpus fluviatilis* with *Salix* shrub zone in background.
3. Association of *Spartina michauxiana* in forground, habitat of *Thamnotettix smithi.*
4. Sand Plain showing *Andropogon furcatus* association, food plant of *Thamnotettix pallidulus.*
5. Lagoon Aa showing short growth of *Juncus-Eleocharis* along margin.
6. Marshy area along horseshoe pond, showing *Typha-Scirpus* zone, also wet meadow with mixed vegetation containing young willows.

Plate XXXV.

1. Marsh area with *Eleocharis acicularis* association.
2. Association of *Scleria verticillata* and *Eleocharis obtusa.*
3. Sand plain showing patches of *Panicum villosissimum* and *P. hauchucae,* food plants of *Deltocephalus apicatus.*
4. Association of *Cyperus diandrus.*



D. M. DeLong



D. M. DeLong

OBSERVATIONS ON THE BELLURA

By Ellen Robertson-Miller.

In the early days of my insect study Professor Comstock told me about an odd caterpillar, *Bellura gortynoides*, which lives in the leaf-stems of the yellow water-lily, *Nymphæa advena*. He called it the Diver, because of its peculiar habits.

The insect interested me, and as I found little had been written about its life history I determined to make a personal study of the creature.

On the 3rd of the following October, at Myers Lake, near Canton, Ohio, the opportunity came to begin this work. B. V. and I were in a boat collecting aquatic material when she noticed a yellow lily leaf that had a hole in its surface directly above the petiole and opening into it. She pulled up the stem, and with such force that a dark, oily-skinned larva, some 4.5 cm. long landed on my knee.

I knew that B. gortynoides caterpillars had been reported from lakes where the yellow pond lily, Nymphæa advena, grows, while *B. melanopyga* was said to live on Nymphæa americana. Only advena is at Myers Lake, so I concluded that our find must be B. gortynoides, the Diver. We began searching for tunneled petioles, and found many, but the greater number were empty.

A kind of turret—the frass of the larva—about the opening on the leaf usually indicated that a Bellura was living below; but we soon discovered that the gallery in a stem might extend through its entire length, and if occupied the larva would "dive" to the bottom of its burrow if it felt its home disturbed. Several caterpillars escaped in this way before we learned that we should pick long stems to secure the inmates.

However, we secured six specimens, all nearly of a size, and by placing the inhabited leaves and plenty of fresh ones in a tub of water we gave the larvæ as nearly natural conditions as was possible, and left them until the following day.

I then removed and examined one of the caterpillars. It measured 5.5 cm. in length, its color on the dorsum, a dark drab, gradually became a light yellowish gray on the ventral

surface. The dorsal half of the twelfth segment seemed to have been sliced away, leaving exposed a posterior area on the eleventh segment, where the caudal spiracles, transposed from their normal side position, were located. These were larger than the other spiracles.

This specialized breathing arrangement for Bellura caterpillars may have required long years for its perfecting, but how clever it is! A larva can stay concealed all day in the stem of its water-plant, just backing to the entrance when its air reservoirs need refilling, or it can remain submerged for hours, as I discovered later, because of the size of these reservoirs.

The head of the caterpillar was a light chestnut-brown. On either side and close to the adfrontals on the epicranial lobes there was a small crescent-shaped pit, one tip of which became a gray ruga extending toward the vertex. Other rugulæ crossed the frons and cheeks somewhat horizontally, and as I learned later, they are less pronounced on gortynoides than those on the head of Arzama obliqua (Bellura obliqua), and are slightly different from those on Bellura melanopyga. The clypeus was lighter than the frons. The frontal suture was peculiarly waved, and I have found this a characteristic feature of B. gortynoides. The frons was stalked.

The antennæ were light, except for a dark encircling mark where the joints came together, and for the dark terminal joint.

The eyes, six in number, were arranged five in a semi-circle and the seventh back of the lower one. The three in the center were pigmented, the others lacked color. The thoracic shield was dark, and there was a dark spot on each of the prolegs, those on the anal claspers being pear shaped. The spiracles, normally placed excepting on the eleventh segment, were outlined in a lighter shade than that of the body color.

Two days after finding the larvæ we saw that all had made galleries in fresh stems. The larvæ ate the green tissues of the leaves usually at night, and they never remained long exposed after a meal.

By the 10th of October two of the caterpillars had stopped eating and I assumed that they were preparing to pupate.

Because of the ease with which these Belluras swam through the water I thought they might pupate on shore in the ground, so I partly filled a can with damp sterilized earth and placed the larvæ in the can, covering it with a sheet of glass. Within

ten minutes one crawler started digging into the earth and was soon entirely concealed. There it remained for three days. Then I saw a second larva burrowing, and as it disappeared the head of the first one, followed by its body, reappeared and began moving about in a very lively manner. I replaced the glass and left the caterpillars to adjust their difficulties.

They went back into the earth and three others followed their example within a few days; but the sixth larva fed until the 8th of November, when, there being no more food leaves, I dropped it into the can and saw it disappear as had the others.

Two weeks later I carefully removed the dirt from the can, expecting to find the caterpillars changed into pupæ; this was not the case, however. Instead there were four larvæ, each curled in its separate cell. They were in good condition and when disturbed grew quite lively. But what had become of the other Belluras? Were they eaten by their companions? The can had remained closely covered and undisturbed.

I left it out in the cold until December, when I again opened it and saw a larva resting exposed on the dirt. A little probing disclosed a second crawler safe in its underground cell. I did not investigate farther at the time, but late in January I saw that the exposed caterpillar had died from a white fungus that was in possession of its body.

Little by little I removed the dirt from the can. It was still damp and molded largely into irregular pellets. I located one oval cell 22 mm. long, with walls slightly cemented. It was intact but empty, and there were no caterpillars where six had been.*

Larvæ thought to be B. gortynoides had been found at Ithaca, N. Y., under the bark of an old post at the water's edge, so late the next April I was at Myers Lake searching for hibernating caterpillars. I found three. They were in oval cells under the bark of old, damp logs, but the logs were not submerged. The cell had been bitten out of the wood by the insect and the particles of wood fiber pushed back so that they formed a wall around its body.

These caterpillars had darker heads than those found in October and the sculpturing on the faces seemed to me, even then with my lack of experience, different from that which I had seen on the lily-feeding larvæ.

*Later experiences with Bellura larvæ lead me to conclude that they are cannibalistic under certain conditions.

In time two of the crawlers developed into moths, a male and a female, and were identified as *Arzama obliqua* (Bellura obliqua), a species which is found living and usually pupating in cattails, *Typha latifolia*, and with which I was somewhat familiar through information sent me by Mr. Charles Rummel, of Newark, N. J. The third caterpillar died.

Early in June I examined moths taken by a friend at Congress Lake, near Canton, with the hope that I might find among them a B. gortynoides. I did not, but there was an Arzama obliqua pinned to a mounting-board. She had revived after being placed on the board and had laid eggs in a kind of silken nest formed by threads of mammalian glue exuded with them. The mass suggested a spider egg-case, and it was this case that led me to look on the Nymphaea leaves for similar cases, which might prove to be those of B. gortynoides.

The next day, June 12, at Myers Lake, B. V. and I discovered them, three egg masses, each on the upper side of a Nymphaea leaf. They were irregular in form and one was much more silky than the others.* I measured an egg mass. Its base dimensions were approximately 8 mm. by 3 mm. As I did this it became detached and slipped from the leaf.

This accident enabled me to see the underside of the eggs. They had been laid in a flat mat of twenty and were small, the individual egg being but .9 of a mm. in diameter. It was hemispherical, pale amber in color, and through a binocular microscope the surface was seen to be finely pitted, giving it a slightly granular appearance. After the eggs hatch the shells lose this color and become a dirty white on the outside, but show a pearly inner surface.

On June 15th minute gnawings of the green leaf-tissue were in evidence about an egg mass, and a day later I saw fine runways radiating from the nest. The larvæ were eating the green chlorophyl-bearing tissue of the leaf. The young caterpillars entered the leaf as near their shells as was possible, and the shells soon after loosened and disappeared.

When I found that the eggs were hatching I probed among them and removed a tiny larva. It had a light body, tinged

*I have learned in later years that freshly exuded eggs are covered by silvery white threads, but that these soon mat into a gray parchment-like covering that in color, texture and size suggests the cocoons of certain small Gyrinidae beetles that are attached to water-plants.

with green, and there were a few dark hairs on the skin. The head and the shield were brown and the caudal spiracles could be readily located. With the first molt the head and shield became a lighter brown and the body of a glassy cream color.

The weather was hot, I was rearing the larvæ some distance from where their food-plant grew and I found it difficult to keep the lily leaves fresh. So I put a section cut from a lily root, with a few young leaves attached, in a globe of water and placed the decaying leaf with its Bellura family upon it. Four of the semi-helpless caterpillars (they were molting for the second time) survived, and they ate so much that by the middle of July every leaf had been consumed and the stems tunneled.

In maturing the caterpillars changed to a grayish-yellow, and when 3 cm. long began burrowing in the stems.

As I could obtain pickerel-weed (Pontederia cordata) more readily than Nymphaea leaves, I placed it in the globe and the Belluras began feeding at once.* And after that they ate the leaves of one plant as readily as those of the other.

A single larva occupied a stem and always entered it at the top through the leaf surface, but in the open, I have found stems entered from the side.

At the end of July the caterpillars averaged 4.5 cm. in length, but they were not so dark in color as those taken in October.

I had supposed B. gortynoides to be a single brooded insect and was surprised on August 8th to find two of the larvæ shortened for pupation and a third already in its pupa form. This pupa, in the upper part of a tunneled stem, was slender, slightly curved, .25 cm. long and of a deep brown color. The eleventh segment of the pupa retained the caudal spiracles, and was also ornamented by a pattern on the dorsal side done in graceful lines, which looked as if they had been "tooled" on the surface, while the surface was soft and pliable.

It was not the only segment with special decorations, however. The eighth, ninth and tenth each bore a decided ridge, finely toothed and divided into dorsal and side scallops, while on the twelfth there were two pairs of sharp, stiff spines that curved backward and upward.

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* Bellura and possibly Arzama larvae are found in stems of P. cordata.

A female moth emerged from this pupa on August 20th. The front wings were like pale gold, with purplish-violet markings across them. The antemedial line was slightly dentate, the postmedial line decidedly dentate and excurved from costa to vein 4. The sub-terminal line was dentate, darker than the other markings and so curved that it made three scallops in the gray-lilac terminal area. The reniform in the wing was yellow, but scarcely discernible, and a rather wide band of the purplish-violet crossed the wing midway of its length and bent near the center so as to form an acute right angle.

The gold of the hind wings was suffused with rose madder, and this color largely obliterated the markings except for the pale yellowish outer border. On the under surface, the front wings were irrorated with pinkish-violet, quite pronounced in the terminal area, and this color was carried across the lighter hind wings in a curved line, and there was a dark discoidal spot in each under wing.

The body and the tufted thorax had the golden color of the fore wings and there was a bunch of shining white caudal hairs on the abdomen, indicating, according to Hampson, that the moth was Bellura gortynoides. The beautiful white of these hairs, which is so noticeable when the moth emerges, soon become dull and less conspicuous.

This moth was the only adult reared from the eggs found on June 12th, but B. V. had mailed me several pupæ, each in burrowed Nymphaea stems, and a few mature larvæ. One of the latter pupated within the rolled edge of a lily leaf on August 17th and yielded a male moth.

August 23rd I found him resting with wings held in roof fashion and the tip of his dark-pointed abdomen extending from beneath. The thorax was well tufted, reddish and deepening in tone toward the head. This color irrorated the wings, whose maculation was similar to that of the female except that the reniform of light orange was well defined.

At Myers Lake I saw no moths of this kind, but there were empty pupa-cases in the lily stems, and with some of these there were pupariia of a fly identified by Dr. Aldrich as Masicira senilis, a parasite that deposits living maggots, which prey upon Bellura caterpillars.

I located egg nests but nearly all the shells were empty. I failed to carry larvæ from the eggs through to the adult period, and this has been my experience in more recent years.

The larvæ hatched from late summer eggs I reared separately after they entered the Nymphaea stems, and I gave each a can of sterilized earth or a piece of damp sterilized wood with bark on, in which to hibernate. They used both, but in only one instance was a pupa formed. This was on April 27th, and the insect was alive on May 18th. On May 21st it remained inactive, and I noticed white fungus between the segments. I removed the moth—perfectly formed. I could see the bunch of caudal hairs, but I could not determine the markings of the wings.

Is B. gortynoides seasonally dimorphic? Why are the moths so difficult to find in the open?

Late last September I discovered three Bellura caterpillars in a Nymphaea root; one had entered at the attachment of the leaf. Is it possible that these caterpillars winter in the roots of their food-plant, reaching them through the tunneled stems? I am inclined to think it may be so since reading Dr. P. W. Classen's interesting account of Arzama obliqua, in which he says its larvæ are found in closed cells in cattail during the winter, completely surrounded by ice, and that they pupate in these cells.*

But if Nymphaea roots are used for hibernation where do B. gortynoides pupate? Mature larvæ are never seen in the early spring.

OBSERVATIONS ON BELLURA MELANOPYGA.

On November 11, 1921, at Eustis, Florida, I found a group of eggshells on a leaf of *Nymphaea americana*. The eggs had been placed in a pile and they were covered with gray mammalian glue. The individual egg was white, opaque and semi-spherical in shape. The mass covered an irregular surface of about 3 mm. by 4 mm., and resembled the old egg masses of B. gortynoides found on Nymphaea at Myers Lake.

A well-grown B. melanopyga larva taken from a Nymphaea stem had a deep gray color with the posterior edge of the segments darker. This gave to the insect a slightly banded

* Typha Insects: Cornell University, Memoir 47.

appearance. The under side of the body was light. On the anal claspers there were four black tubercles, a hair arising from each, and on the caudal tip six tubercles. The claws were very dark.

The head was not deeply rugosed, the sculptured lines flowed downward from the vertex, much as they do in A. obliqua, but they were shorter. The frons was light brown and was crossed by four broken horizontal grooves. The frontal suture was dark brown. The adfrontals were like the frons in tone, and were distinctly set off from the epicranial lobes by a light line.

Other larvæ of about the same age had skins so dark that no banding was discernible on their bodies.

At the same time I collected pupæ. Each rested at the top of a burrowed leaf-stem.* The pupa cases were a dark brown. The caudal spiracles were not so conspicuous as are those of B. gortynoides, and the posterior ridges of the segments were not so ridged or toothed. The anterior portion of a pupa was rough, and on its vertex was a double tubercle.

On December 1st the first adult—a female—emerged. The color of the moth was a light ocherous-tan, with markings of purple-brown. The maculation was similar to that of the female B. gortynoides only the colors were not so brilliant, and the tuft of hairs at the tip of the abdomen was quite dark. Later this color became faded. The moth was identified as B. melanopyga by Mr. Foster H. Benjamin.

On December 15th a male moth emerged. The head and thorax were of a brownish-ochre, the head much the darker, but the abdomen showed little of the brown color. The fore wing was golden-ochre, marked and irrorated with brown madder—most thickly on the median space. The antemedial line curved and was minutely waved. The postmedial line was dark, dentate, excurved, then oblique to the inner margin. The subterminal line was minutely waved, excurved below vein 7 and at the middle, then it bent outward to tornus. There was a fine dark terminal line and the terminal area was of a gray-violet color.

The orbicular and reniform were golden-ochre and conspicuous in an area darkened by madder brown. An oblique

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* I find pupae of B. gortynoides lower in the stems.

line of this color extended from the median cell to the inner margin. The hind wing was red ochre on its upper surface; but little of the red showed on the lower surface except in a wide terminal band and as a dark discoidal spot.

A goodly number of moths were secured. They varied slightly in color and in intensity of markings. The males were always the more beautiful, and they resembled so closely the female B. gortynoides that I was not surprised when Mr. Benjamin, who kindly examined and identified my Bellura and Arzama material, wrote that he was unable to separate the male moths of melanopyga from the males of gortynoides in the Dr. Barnes collection, and that my Eustis males might belong to either species. But as larvæ from which the male and female moths developed came from the same habitat, and as only Nymphaea americana grew there—the food-plant of melanopyga—it seems logical to conclude that the males belonged to the same species as the females.

Dr. Paul S. Welch has made a careful study of the habits of the larvæ of B. melanopyga, which are recorded in the University of Michigan Biological Bulletin, No. 2, Vol. XXVII. He did not find eggs, but very young caterpillars mining and feeding in the lily leaves.

The specimens which I took at Eustis were well-grown and they had reached what Dr. Welch calls the petiole period. Because of what I learned of the insect through Dr. Welch and through my own observations of melanopyga and of gortynoides, I conclude that the two species of Bellura are very similar in behavior as well as in appearance.

EXPLANATION OF PLATES.

Plate XXXVI.

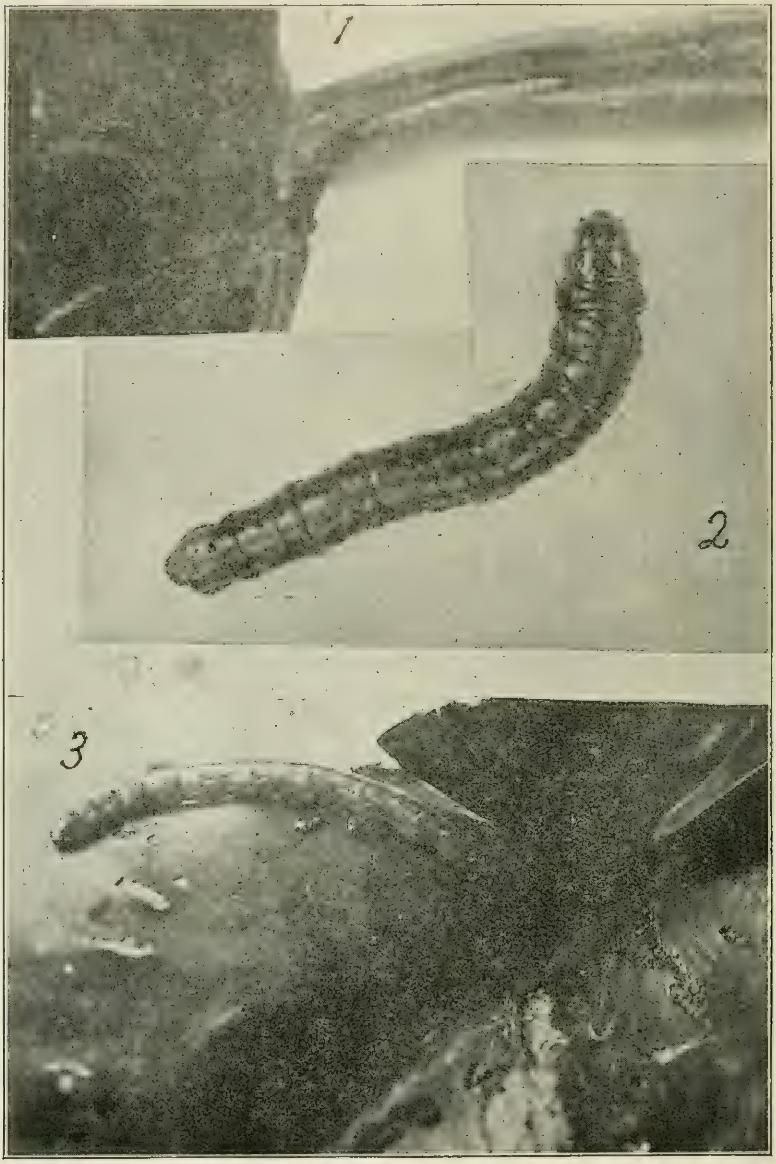
1. A young, light colored B. gortynoides larva, life-size, in the stem of the leaf. On the surface of the leaf three runways made by the small mining caterpillar are to be seen.
2. B. obliqua larva. Length 5 cm.
3. B. gortynoides larva on Nymphaea leaf, and the opening to its burrowed stem.

Plate XXXVII.

4. Female B. gortynoides moth. Spread 40 mm.
5. Male moth of B. gortynoides. Spread 34 mm.
6. Egg mass of A. obliqua. 7 and 8—Egg nests of B. gortynoides. One showing the minute gnawings of the larvae. (Slightly Enlarged.)
9. and 10. Female and male Arzama obliqua moths, life-size, which developed from larvae found under bark June 1st. ♂ had a white tip to abdomen.

Plate XXXVIII.

11. Egg mass of B. gortynoides. Base dimensions approximately 8 mm. by 3 mm.
12. Tenth, eleventh and twelfth segments of B. gortynoides pupa, showing the scallops and tooling.
13. Pupa of B. gortynoides.



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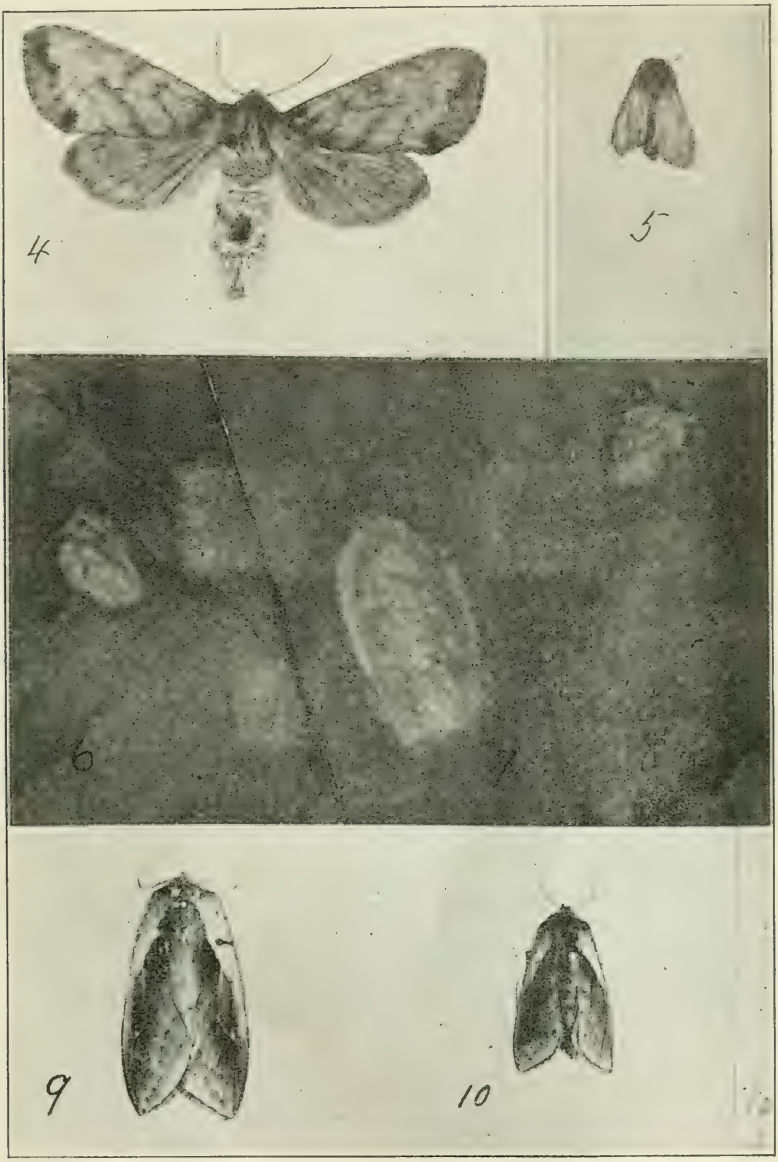

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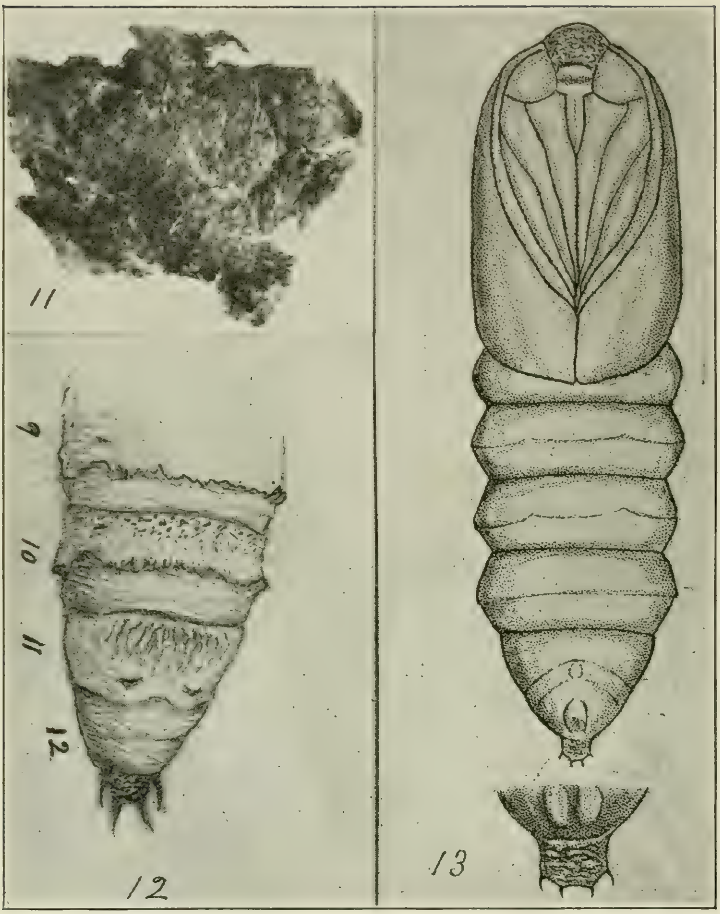

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HOLOSIRO ACAROIDES, NEW GENUS AND SPECIES,— THE ONLY NEW WORLD REPRESENTATIVE OF THE MITE-LIKE PHALANGIDS OF THE SUBORDER CYPHOPHTHALMI

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During the spring of 1912 while collecting insects and mites in the foothills of the Coast Range Mountains in western Oregon a number of small mite-like arachnids were observed on the moist soil under a small log. When first seen they were taken for Gamasid mites, and not being particularly interested in the family Gamasidæ, the writer picked up only two specimens. Later after reaching the laboratory, greatly to my surprise, I found that what I had taken for mites were not mites at all, but were mite-like phalangids, more mite-like apparently than any of the phalangids yet described.

Of the two specimens taken, one proved to be a mature female, and the other apparently an immature male. With only this scant material at hand it was deemed best to wait until further specimens could be obtained before attempting any description of the species. My search for other specimens, however, proved vain. On several occasions the same identical spot in the foothills was visited and searched but not here or at any other place among the scores of localities visited the next three years was a single additional specimen found.

Several years having now passed and in the meanwhile, the writer having come to the city of Washington some thousands of miles away from the scene of the capture of this interesting arachnid, the probability of never being able to take any more specimens appears imminent. Because of this probability it appears best now to record the discovery and to describe the arachnid that was found.

As will be seen by observing the figure (Plate XXXIX) of the phalangid, the abdomen shows no evidence of segmentation above; the legs are short and seven segmented; eyes are absent; and a single claw terminates each tarsus.

It should be added, however, that while the adult shows no evidence of abdominal segmentation above, the immature individual shows eight segments dorsally. It should be stated though that the immature specimen differs from the adult in so many characters that no assumption can be made that it is of the same species. The new genus and species, which belongs to the family Sironidæ of the suborder Cyphophthalmi of the Order Opiliones, is here described.

Holosiro, new genus.

Tubercles containing the opening of stink glands situated dorsolaterally above coxæ II and III and projecting beyond the side margins of the body. Metatarsi about half as long as the tarsi. Tarsi of legs I and II simple but of legs III and IV (Fig. 1) flattened, subfoliaceous, two rayed, notched on the posterior margin and bearing a clavate sense organ above near the tip. Maxillary lobe of coxa I very broad, hence coxa I proper not contiguous with maxillary lobe of coxa II; terminal portion of pars manducatoria of the chelicera seen as a very minute area at the median margin of maxillary lobe of coxa I; tergite IX fused with sternites VIII and IX. In the adult state all dorsal abdominal tergites are fused into a great dorsal plate which not only completely covers the abdomen dorsally but extends laterally even on to the ventral side of the same.

Type species.—Holosiro acaroides, new species.

This genus is related to *Siro* Latreille and to *Parasiro* Hansen and Soerensen, probably more nearly to the first named, from which it differs in the shape and relationship of the maxillary lobe of the first coxa, in the character of the tarsal claws of legs III and IV and in the complete fusion of the abdominal tergites. It differs from *Parasiro* in the relative length of the tarsi to metatarsi, in the nature of the last two sternites and last tergite, in the tarsal claws and in some other respects.

The species is described as follows:

Holosiro acaroides, new species.

Adult female.—Body elongate, forming almost a perfect ellipse, and integument tuberculate. Cephalothorax almost completely fused with abdomen above; it is broadly and evenly rounded in front and slightly constricted behind the dorsal tubercles of the stink glands. These latter structures are cone-shaped, rounded at the tip and about as broad at their bases as they are high. Coxa I with large maxillary lobe which is fully as long as the coxa proper, inner margin almost straight and reaching median line, front margin concave, outer margin mildly convex and posterior margin, which is contiguous with the

anterior margin of maxillary lobe of coxa II for most of its length, almost straight. Coxa I proper is wedge-shaped internally. Maxillary lobe of coxa II somewhat comma-shaped, with the tail of the comma swollen on the inside. Coxa II proper a long band of chitin with almost parallel sides. Coxa III about as long as II but somewhat wedge-shaped. Coxa IV fully one-half as broad as long. Genital opening arched in front and partially covered behind by a projecting margin of chitin. Each coxa has several setæ; maxillary lobe of coxa I with a single seta which is situated at the outer posterior angle; maxillary lobe of coxa II on the left side with six setæ, on the right with seven.

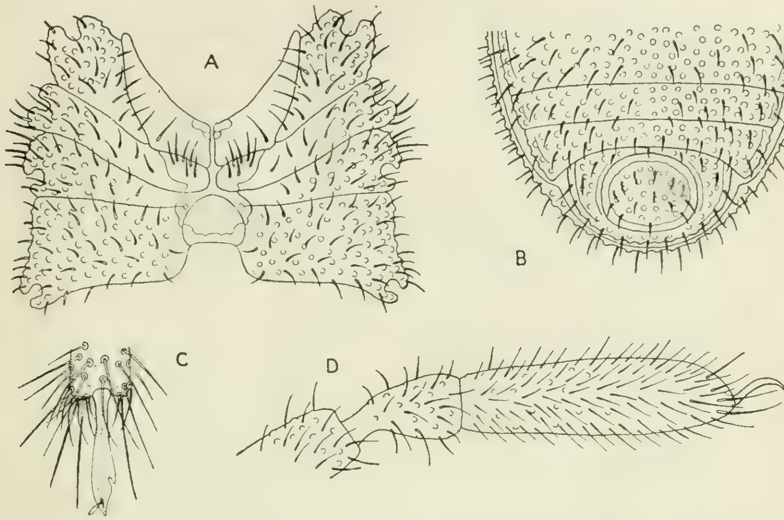


Fig. 1. Details of *Holosiro acaroides*, new genus and species; *a*, ventral view of cephalothorax; *b*, ventral view of tip of abdomen; *c*, dorsal view of tip of tarsus IV; *d*, side view of tarsus and metatarsus I.

Mouth-parts of the usual type of the family Sironidæ. Cheliceræ reaching to about the middle of the first coxæ; movable and fixed arms subequal and each with 6 to 7 teeth; pedipalps long and slender reaching to about the middle of tibiæ of first pair of legs; last segment about three-fourths as long as next to last and terminating in a simple claw.

Legs similar; first and last pairs subequal and slightly longer than the second and third pairs. Tarsi of legs I and II simple; of legs III and IV (Fig. 1) rather complicated and as described in the generic diagnosis of *Holosiro*. Metatarsi of all the legs somewhat curved, decidedly pedicellate and scarcely half as long as the tarsi. Tibia of leg I almost twice as long as metatarsus of leg II somewhat shorter, and of leg III and IV but little longer than metatarsus.

Abdomen of same width as cephalothorax; sparsely clothed with short setæ and more strongly tuberculate than the legs. Dorsal sclerites 1-8 fused, 9 united with ventral 8 and 9 to form a single sclerite which

includes the circular dorsal 10. Peritreme subtriangular and situated in a depression just lateral to hemispherical tubercle. Ovipositor, in repose, extending from near the front margin of sternite 6 almost to the genital opening. It ends distally in three finger-like processes and is remarkably similar in shape, structure and position to the ovipositor of the beetle mites.

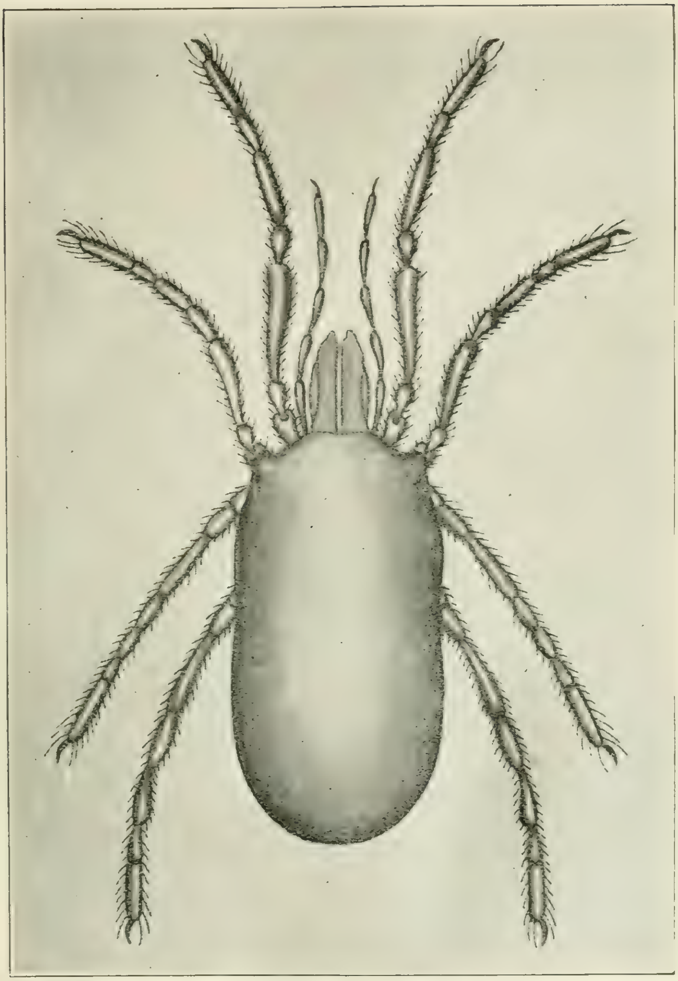
Length exclusive of cheliceræ, 1.8 mm.; width, 0.85 mm.

Type locality.—Foothills of Coast Range Mountains, Benton County, Oregon.

Type.—Deposited at the United States National Museum.

Described from a single adult female, the holotype. An apparently immature specimen has the abdomen distinctly segmented above as already stated, but differs from the adult in so many particulars that there is no assurance that the two are of the same species. In this individual the ventral sclerites of the abdomen are as represented to exist in *Parasiro* and not of the *Siro* type as they are in the adult female. In this specimen, also, the tarsal claws of the last two pairs of legs are not expanded and have no sensory organ, but each has one or two teeth situated somewhat ventrally. It is also noted that in this apparently immature individual that the integument is pitted, not tuberculate, and that the maxillary lobes of coxæ I and II are quite differently shaped.

A note must be added in closing on the remarkable acarine affinities of this phalangid. First of all we here have a species in which all superficial indication of the segmentation of the abdomen dorsally is lost. Secondly, the number of segments in each of the legs and their arrangement is exactly the same as in certain mites, the Labidostomatidæ and the Opilioacaridæ for example. The number of segments (6) in the palpi, or pedipalps, is the same as in the mites of several families including the Gamasidæ and the Labiodostomatidæ. Further, the tubercles for the opening of the stink glands are in almost exactly the same position as are the tubercles of unknown function in *Labidostoma*. In regard to the stink glands of the family Sironidæ it is interesting to note the similarity of their structure and position to the lateral (excretory?) glands found in the mites of the family Tyroglyphidæ and in young of the Oribatoidea and in some instances also in the adults of the same superfamily, in which cases they open on tubercles as in the *Sironidæ*.



Holosiro acaroides, new genus and species.
Dorsal view of female, X 30.

H. E. Ewing

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